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ORIGINAL ARTICLES.

I.—On some Palæolithic Flake-implements from the High Level Terraces of the Thames Valley.

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(PLATE II.)

OVER most of North-Western Europe the occurrence of river-terrace deposits containing Palæolithic implements has been long known, and the establishment of a sequence of forms among these implements has resulted from the researches of Continental, and especially of French archæologists. With the pioneer work the name of M. Boucher de Perthes,[1] of Amiens, will always be associated. His was the task of convincing unwilling minds of the human workmanship of the ancient flint-weapons found in the gravel-pits of the Somme Valley. For the next great advance we owe a debt of gratitude to another French savant, the late Professor Victor Commont,[2] for his life-work was the taking up of the researches of his predecessor and establishing the sequence of cultural types and their relative chronology.[3]

Flint implements of the same forms had long been known to occur in the gravels of the Thames Valley; but as their precise stratigraphical position had never been ascertained, it was held generally that the several forms occurred on one and the same horizon. This assumption, based on careless collecting, became a strong prejudice in the minds of some archæologists, but no efforts were made to test by proper investigations the truth of the hypothesis they held. In view of the conclusions arrived at by the Continental authorities, however, it was certainly desirable to examine at home the validity of the stages of palæolithic culture they had found to hold good abroad.[4] Some investigations were therefore undertaken in the years 1912, 1913, and 1914, by the Geological Survey and the British Museum, in co-operation, at

[1] *De l'industrie antiquitées Celtiques et Antédiluviennes*, Paris, 1847.

[2] *L'Anthropologie*, xix, pp. 527–72, 1908; *Compte rendu de l'Association Française*, 1908, pp. 634–45; *Assoc. Préhist. Congrès de Lille*, 1909, p. 437; *Revue préhistorique*, 1909, No. 10; *Bull. Arch.*, 1911, p. 27; *Congrès international d'Anthropologie*, xiv, p. 240, 1912.

[3] The names of Prestwich and Lyell, and later those of Messrs. Spurrell, W. Smith, Kennard, Leach, and Chandler, should, however, be mentioned in connexion with the advance in scientific classification of the Palæolithic periods.

[4] These stages are in descending order: Azilian, Magdalenian, Solutrean, Aurignacian, Moustierian, Acheulian, Chellean, Strépyan.

various sites in North Kent and near Rickmansworth. The results are published in *Archæologia*,[1] but a brief account of these results is necessary for the discussion of the present paper. All the flake-implements illustrated[2] in Plate II, and described on pp. 53–5, were collected by the author, or in his presence, at these sites during visits made to the pits after the publication of the official work.

The chief interest attaching to these flake-implements is the light they throw upon the ancestry of the types that became dominant in the cave periods and in the Neolithic age. During the early palæolithic periods core-implements were characteristic and predominant; in the early cave period (Le Moustier) flake-implements suddenly, and almost completely, replaced them; but that the pattern was not unfamiliar to the earlier peoples is proved by the occurrence of similar types, and it may therefore be concluded, either that the earlier men were not in such urgent need of these forms, or that they preferred the use of others.

The age of these flake-implements is indicated by the position in which they were found.

Deposits of the 100 ft. Terrace of the Thames.

The first site selected for investigation was the large gravel-pit, at Milton Street, near Swanscombe, known to the owners (The Associated Portland Cement Manufacturers) as the Barnfield Pit. The Company, through one of their Managers, Mr. George Butchard, courteously invited the British Museum and the Geological Survey to undertake an examination of the sand and gravel for flint implements before this overburden was removed, preparatory to the quarrying of the underlying chalk for making cement.

A preliminary visit showed that over the whole area around the pit there was a persistent series of Pleistocene deposits composing a 35 ft. section. As the deposits had already been removed to various depths at different parts of the pit it was possible to examine nearly every bed without shifting those above, and the danger of mixing the beds was thereby avoided.

The following sequence was found to occur:—

	Feet.
Soil.	
Gravel, irregular pockets and pipes in stiff clay (the Upper Gravel)	4½
Loam (the Upper Loam)	
Gravel and current-bedded sand (the Middle Gravel) . . .	8–18
Loam and Marl (the Lower Loam)	2–4
Gravel (the Lower Gravel)	5–6

On the northern side of the pit the gravel overlaps the Thanet Sand and lies directly on the Chalk. The overlap is due to the general southerly dip.

About two weeks' digging resulted in the collection, and accurate location, of many palæolithic implements and rough flakes, and

[1] Vol. lxiv, pp. 177–204, 1913; vol. lxv, pp. 187–212, 1914; vol. lxvi, pp. 195–224, 1915.

[2] For these drawings and descriptions I am indebted to my friend Mr. Reginald A. Smith, of the British Museum.

sufficed to prove that there was a sequence of palæolithic types corresponding to a succession of Pleistocene deposits.

The beds of the lower gravel contained many large flakes without secondary working, and a few cylindrical nodules either chipped into a chisel edge or roughly pointed at one end. These resemble some of the implements discovered by Dr. A. Rutot from a locality known as Strépy, in Belgium. No true palæolithic implements, however, were found in this gravel.

The Middle Gravel contained a large number of true implements, those found near the base being of rougher workmanship than the smaller number lying at the higher levels. From the lower part nearly all were of "pear" shape, many carefully worked and devoid of cortex, while others were rougher, with much cortex remaining at the butt end. There was also a large number of chips and flakes without signs of trimming or usage, many closely resembling, except in size, the flakes from the Lower Gravel. Only four worked scrapers were afterwards found at this horizon, two round scrapers and two pointed forms (see Pl. II. Figs. 1, 3, 5, 6). None of the implements shows the slightest mark of abrasion, a fact which seems to indicate that they had not travelled far, but had rather been dropped into the river somewhere in the neighbourhood during the time the gravel was collecting. They are strictly contemporaneous, therefore, with the gravel and not derived from an older source. Moreover, as no forms characteristic of higher levels occurred with them the gravel in question may be assigned to one period.

In the Upper Gravel no implements were found, but the workmen stated that implements of ovate form and white patination had been found in the clay of this gravel-bed. On the eastern side of a road (Craylands Lane) bounding the Barnfield Pit, a small gravel-working had been opened. This deposit, which lies at a slightly higher level than most of the Middle Gravel, is current-bedded and overlain by even-bedded gravel with clots of clay and pebbles filling channels in its surface.

At the top of the current-bedded gravel some sixteen implements have been found. They are all ovates, most with the edge curved like a reversed S and patinated white. In other words, they are typical St. Acheul forms, and being practically unrolled must be contemporaneous with the gravel in which they were discovered.

All these deposits lie on a widespread terrace-platform cut by the Thames in the Chalk and Thanet Sand. The base of the Pleistocene beds is about 90 feet above the Ordnance Survey datum, and the deposits are described as those of the 100 ft. terrace of the Thames.

To summarize the evidence derived from these stone implements for a complete "Drift" sequence in the deposits of this terrace it has been seen that the lowest gravel contains no true palæolithic form. In the Middle Gravel all the forms may be assigned to the Chelles type of the Somme Valley, and especially to those of the lower series at St. Acheul.

The small collection of ovate forms from the pit east of Craylands Lane can be assigned provisionally to the St. Acheul type, as they are all of ovate form; several have a characteristic pronounced twist

in the usual direction, and many have the white or cream patination so frequently found at St. Acheul.

In another pit (Globe Pit) near Greenhithe a flake-implement having a china-white patination was found in loam from which forms assigned to the Le Moustier period have frequently been collected. A racloir flake belonging to the St. Acheul period was dug out of the clay of the Middle Gravel.

Subsequently to the deposition of the 100 ft. gravels a tributary of the Thames, the Ebbsfleet, cut out a valley some 50 feet deep. This valley was afterwards partially filled up with an unstratified mass of chalky rubble, sand, pebbles, and clay containing a number of bones, teeth, and tusks of various extinct mammals. At the base of this rubble, and lying on a fairly even floor, many thousands of flakes, cores, and implements have been found. The cores resemble the carapace of a tortoise, and the worked flints are characterized by a peculiar faceting of the platform or striking-plane. The core was carefully flaked and a complete implement struck off at a single blow on one of the facets, but the underside carried an enormous bulb of percussion.

Precisely similar forms were discovered by Professor Commont, who succeeded in dating the finds as belonging to the early part of the Le Moustier period. In the Ebbsfleet Valley the flake industry had very nearly replaced the core implement, as has already been described by Mr. Reginald A. Smith.[1]

The investigations at Mill End, near Rickmansworth, were less decisive in their results. They were undertaken in the large gravel-pit where some 16 feet of red gravel with seams of sand are exposed. A peculiar feature of the gravel is the occurrence of large cave-like spaces, which may have been formed by the thawing of frozen masses of sand. These deposits rest upon a wide terrace flanking the River Colne. Palæoliths of Chelles type have been found in abundance in the past; in fact, nearly every implement that has come from this pit is of the early Chelles coup-de-poing form, with heavy base and acute point. The Croxley Green pit, higher up the river, on the other hand, has yielded numbers of the early St. Acheul, ovate, type of implement.[2] As a result of the joint examinations by the Geological Survey and the British Museum, but very few implements were found, although such as were discovered supplied confirmatory evidence of Sir Hugh Beevor's conclusions.

One good flake-implement resembling a coup-de-poing, but probably a racloir, was secured by the author: it is figured in Pl. II, Fig. 7, and may be compared with one found by the late Lieut. C. H. Cunnington at Knowle Pit, Savernake. The two implements are very nearly identical as regards workmanship, shape, size, and use.

These British deposits and their contained implements may now be compared with those examined by Professor Commont in France. He worked out in detail the palæolithic sequence in the Pleistocene deposits of the terraces in the valley of the Somme. There are there four terraces representing the succession of levels at

[1] *Archæologia*, lxii, 532.
[2] Sir Hugh Beevor, Proc. Geol. Assoc., xxi, 245.

which the river has undercut its banks since the Pliocene period. The deposits of the highest terrace are Pliocene, and no flint implements have been found in them. The second terrace deposits are early Pleistocene and contain Strépyan forms; the third, or 30 metres, terrace gravels have Strépyan forms at their base, and in the sands near the top implements assignable to early Chelles. Upper Chelles types are plentiful in the gravels of the lowest terrace. Sweeping downward from the plateau over these terraces are two mantles of loam, an earlier and a later, called respectively the older and the younger Loess. Each of these Loess deposits is separable into upper, middle, and lower beds—those of the younger Loess being called locally the Ergeron; each seam is underlain by a bed of pebbles, while the surface of each is an ancient soil.

Calcareous concretions, known as Poupeés or Loess-püppchen, occur at the base of both Upper and Lower Loess, those of the latter being larger than the püppchen of the Upper Loess.

The ancient Loess consists in upward succession of (*a*) the *limon rouge sableux*, (*b*) the *limon à points noirs*, and (*c*) the *limon rouge*. In gravels at the base of the *limon rouge sableux* the whole series of forms assigned to the St. Acheul stages are found, but no implements of any kind have so far been found in beds *b* and *c*.

In the younger Loess, and especially in the pebble-beds at the base, the Le Moustier types have been recorded; some occurrences of implements of the later cave periods also occur in this younger Loess.

Most of the Chelles implements are coups-de-poing. This fact is so striking that it led M. de Mortillet[1] to conclude that no other type of implement was made during that period, but more recent finds show that in the Somme Valley as in that of the Thames flake-implements also occur, though rarely, with the other forms. One of these[2] is practically identical in every detail with that figured on Pl. II, Fig. 2, and further corroborates the inference drawn from the English evidence. These curved scrapers possess the characteristics of the racloirs of Aurignacian age found at Châtelperron and to some extent the broad points from the Abri Audi. They are of clumsier technique, and are larger, but evidently designed to meet a similar need.

In the following notes a brief description is given of the implements figured upon Plate II.[3]

Fig. 1.—Large flake of yellow-mottled flint, unrolled, with broad rounded end flaked to form a scraper, the under (flat) face trimmed at end; bulb of percussion and flat striking platform or butt. A median ridge runs half-way from the rounded end, and the side edges are irregularly worked. Length 4·1 in., breadth 3·1 in., thickness 1·1 in. From the lower part of the Middle Gravel at Barnfield Pit, Swanscombe, Kent, for which see *Archæologia*, lxiv, 185. A specimen pairing with this is in the British Museum. It came from the Somme Valley drift at St. Acheul, and has the following dimensions:

[1] Bull. Soc. d'Anthr., Paris, 1887, ser. III, pt. x, p. 173.

[2] V. Commont, *L'Anthropologie*, xix, p. 551, fig. 40, 1908.

[3] [The Editor regrets that the name of the author has, by an accident, been inserted at the foot of Plate II instead of that of his friend, Mr. R. A. Smith, who kindly made the drawings for him.—Ed.]

length 3·7 in., breadth 3·1 in., thickness 1·1 in. An inadequate drawing is included in Lartet & Christy's *Reliquiæ Aquitanicæ*, p. 14, fig. 7. Though rather darker in colour, the character and workmanship are identical, and the form must therefore be recognized, not as an accident, but as a type, though round scrapers or planes are seldom met with in the river gravels. Obermaier reproduces one 3·7 in. long from St. Acheul (Rue de Boves) and classifies it as a *grattoir* (*Die Steingeräte des französischen Altpaläolithikums*, fig. 84) dating not from the earliest but the best Chelles period, when hand-axes were the dominant form.

FIG. 2.—Massive yellowish-grey flake, lustrous and unrolled, with a straight edge on left used as a side-scraper, and on the right towards the top a thick curved edge, worked as a finger rest; bulb of percussion and flat platform at base. Length 3·3 in., breadth 2·3 in. From the pit east of Craylands Lane, Swanscombe. This is a rare form, and might be mistaken for a knife, but the plain underface on the left shows it was used as a *racloir*. The mode of holding such an implement (called a knife) was illustrated by the late Professor Commont in *L'Anthropologie*, xix, p. 551, fig. 40, 1908, reproduced by Obermaier, op. cit., fig. 67*a*; a side-scraper with similar accommodation for the finger is represented in his fig. 99. A few bold striations on the bulbar face of this specimen should not be overlooked.

FIG. 3.—Round scraper on a broad gabled flake, with a spur at one end of the planing edge; of typical "mahogany" flint as common at Swanscombe, with bulb of percussion, large flat platform, and plain flat bulbar face. The side edges are parallel, as in the later blade-scrapers, but the specimen is rather broad for that category. Length 2·7 in., breadth 1·9 in., thickness 0·9 in. A rare form from the Drift, but two specimens somewhat larger were found in the same Barnfield Pit, Swanscombe (now in British Museum), one having a spur in the same position; and a more slender example, from the lower part of the Middle Gravel there, is recorded in *Archæologia*, lxiv, 187 (cf. Obermaier, op. cit., fig. 85, from Rue de Boves, St. Acheul).

FIG. 4.—Yellow-brown ridged flake, with bulb and flat platform at one end and at the other a sloping worked edge ending in a point at the top and extending round a shoulder down the left side. The longer edge on the right also has signs of use, and the plain bulbar face has a number of scratches nearly all parallel with the longitudinal axis. The principal features are the top angle and the steeper shoulder on the left; no doubt used for scraping. Length 3·2 in., breadth 2·1 in. Found in gravel at Milton Street, Swanscombe, Kent.

FIG. 5.—Black and yellow mottled flake, ridged and slightly notched on either side of the thinner end to form a nose; the broader end rounded and underface quite plain, the bulb missing. The working end of an implement is often emphasized by one or two side notches, but the present specimen cannot be classed as a borer. Length 3·2 in., breadth 1·7 in. From gravel at Milton Street, Swanscombe, Kent. Similar specimens from St. Acheul are figured by Obermaier (op. cit., figs. 56, 78) and assigned to the Chelles period.

FIG. 6.—Broad olive-brown flake, with careful shallow working along the right edge, where secondary work indicates use as a side-scraper (*racloir*). The edge near the point on the left is zigzag and bruised, and the lower edge is thick and rough, the bulb remaining in the lower angle on the right. The bulbar face is not flat, and the edge is chipped in places. Length 4 in., breadth 3 in. From gravel at Milton Street, Swanscombe, Kent. The flaking of this specimen, apart from the result of use, seems to be rather in the style of St. Acheul than of Le Moustier, though in form the resemblance to the latter type is very striking. Compare specimens from St. Acheul figured by Commont, *Les Hommes contemporains du Renne*, figs. 45, 51.

FIG. 7.—Triangular hand-axe, lustrous brown, made from a flake, with bulb at angle of base; the side edges nearly straight and the lower edge thick and crusted; worked on both faces along the edges, and the point carefully formed. Length 2·8 in., breadth 1·9 in. From Mill End Pit, near Rickmansworth. (See *Archæologia*, lxvi, p. 196.)

FIG. 8.—Small subtriangular implement, made of an olive-green flake, with crust at the butt and traces of an older ochreous surface on the front. The bulb is at one angle of the base, and the other is the lower limit of the work on the right-hand edge, which must be classified as a side-scraper, as the bulbar face is untouched. Length 2·8 in., breadth 2 in. From Knowle Farm Quarry, Savernake Forest, Wilts. The horizon is unknown, but the specimen has all the appearance of a *racloir* or side-scraper of Le Moustier date. (See *Archæologia*, lxvii, p. 30, fig. 2.)

Examination of any representative collection of flint implements shows that there are assemblages of forms each fashioned after an accepted pattern. Of the palæolithic implements, those belonging to the Drift period are chiefly of a general pear-shape in outline among the earlier deposits, but ovate in the later, but both are flat although made from trimmed *cores*; that is, they are chipped on two faces, and not simply spindle-shaped pieces with sharp points, but flattened cones and discs with cutting edges. With the advent of the Cave periods the core was given up and the flake adopted. Nearly all "cave" implements are made from flakes; some are carefully worked on a disc-face, a facetted platform prepared, and by a single blow on this platform a complete implement detached from the core. By this means half the work expended on their manufacture was saved and the implements were as effective as the earlier core-forms.

Many flakes were used as "scrapers"; some being trimmed along one side to make a comfortable hold which would not cut the hand. As a result of use the scraping edge gradually got chipped off so as to meet the holding-edge, and a triangular form resulted resembling in outline the coups-de-poing. Such are figured on Plate II.

The original implement was a racloir; by use it became a coup-de-poing, but it is doubtful if they were ever used as points.

In the later Cave periods the principal tools were the racloir or side-scraper, the grattoir or plane, and the burin or graver. Among the implements described on pp. 53–5 examples of the racloir and grattoir are noted. The age of the implements is determined by their stratigraphical position; they are either Chelles or St. Acheul. They were therefore evidently used by early palæolithic man, and that they were in use over widespread areas is proved by their occurrence alike in England, France, and Belgium.

What is perhaps of even more interest is the variety of form of the tools, pointing to the differentiation of function and of specialization among the workers. Thus the coups-de-poing, the grattoirs and the racloirs, three kinds of tools, of which each attains its maximum development both as to numbers and style of workmanship at a different period, are all known in the Chelles stage. The early palæolithic forms may therefore be regarded as the ancestral types of the later periods. During the palæolithic periods some tools and weapons decreased in numbers, while others greatly increased. Attending this alteration of dominant form was the gradual evolution from one type to another, and there is no more interesting instance of descent with modification than that of the Neolithic celt from the palæolithic coup-de-poing. This subject has already been dealt with by Mr. Reginald Smith,[1] and it suffices here to say that in any

[1] *Archæologia*, vol. lxvii, pp. 27–48, 1916.

representative collection similar instances could be found. It is to be hoped that the histories of the modification of other characteristic forms may be traced. They are suggested by such forms as are figured on Plate II, and especially the racloirs and grattoirs, and there can be but little doubt that intermediate forms exist.

These modifications of the implements imply changes in the needs of the men who used them; changes brought about presumably by different climatic conditions, the incoming of other animals and plants, and the substitution of co-operation for hostile competition. The decrease in the relative proportion of weapons to tools accompanies the increase of civilization and marks the advent of the artistic races. Co-operation among men was soon followed by that larger co-operation between man and the animals, when the hunter became the herdsman and shepherd; the resulting domestication was perhaps reciprocal.

But it must always be remembered that the histories of the several types of implement could never have been traced without the aid of geology. For certainty as to relative chronology was unattainable until the precise location of the finds was ascertained. Before the necessity of such precision was realized no better classification could be made than that of the late Lord Avebury,[1] who divided all flint implements into palæolithic and neolithic.[2] All that were not of the one age belonged to the other, and all members of each group were considered to be more or less contemporaneous. Geological observations, however, proved the error of such generalizations, and supplied the means of fixing the relative ages of the finds. Flint implements then promised to become of value to geologists as "zone" fossils, and although uncertainty still exists obscurities are being cleared up.

Conclusions.

The early palæolithic implements of France and Belgium have been classified according to their form into two groups, namely, the coup-de-poing or pear-shaped; and the limande, or ovate, forms.

Where these implements occur in river-deposits, e.g. in the Somme Valley, the beds containing the "coups-de-poing" always underlie those with the "limandes".

The "coups-de-poing" are therefore assigned to an earlier or Chelles period and the "limandes" to a later or St. Acheul period.

Later than these implementiferous deposits there are others of a different character in which lie flake-implements known as Le Vallois flakes; or, from their resemblance to the implements found in caves at Le Moustier, as Mousterian.

So far as scientific research has been carried in England a similar sequence has been found.

The dominant types of implements in the Chelles and the St. Acheul periods were made from cores, whereas the Mousterian ushered in a great abundance of flake-implements, among which coups-de-poing and limandes are rare.

[1] But see Lyell, *Antiquity of Man*, 4th ed., 1873, ch. viii-x.
[2] Lubbock, *Prehistoric Times*, 1869.

During the later Cave periods the flake-implements show more skilled workmanship and a greater variety of forms, and this improvement is maintained in the Neolithic age.

The occurrence, however, in the Chelles and St. Acheul periods of most of the types of flake-implements, such as the grattoir, the racloir, and the knife, points to the fact that early palæolithic man was already acquainted with the patterns and methods of making the flake-implements, but for unknown reasons he preferred, or was compelled to use, the core-implement.

Evolution or descent with modification can be traced from some palæolithic to neolithic types, corresponding with changes of conditions and a gradual advance in civilization.

Without the aid of geology no precise chronology among cultural stages could be traced; with its aid, time-relationships can be determined and the several types of flint-implements, instead of being mere *objets de vertu*, acquire a new value as "zone-fossils".

II.—Climate and Time.

By R. M. Deeley, V.P.G.S.

SIR CHARLES LYELL in his *Principles of Geology*, published in 1834, remarks upon the accumulating proofs that the climate of the earth had undergone great changes in the past, and he endeavoured to show that these changes might have been produced by the varying distribution of sea and land. He says, "But if, instead of vague conjectures as to what might have been the state of the planet at the era of its creation, we fix our thoughts steadily on the connexion at present between climate and the distribution of land and sea; and if we then consider what influence former fluctuations in the physical geography of the earth must have had on superficial temperature, we may perhaps approximate to a true theory."

The attitude adopted by Lyell may be well illustrated by a few quotations from chapter vii of the above-mentioned work:—

"The ocean has a tendency to preserve everywhere a mean temperature, which it communicates to the contiguous land, so that it tempers the climate, moderating alike an excess of heat or cold. The elevated land, on the other hand, rising to the colder regions of the atmosphere, becomes a great reservoir of ice and snow, attracts, condenses, and congeals vapour, and communicates its cold to the adjoining country." "Among other influential causes, both of remarkable diversity in the mean annual heat, and of unequal division of heat in the different seasons, are the direction of currents and the accumulation of drifting ice in high latitudes." "If we now proceed to consider the circumstances required for a *general* change of temperature, it will appear, from the facts and principles already laid down, that whenever a greater extent of high land is collected in the polar regions, the cold will augment; and the same result will be produced when there shall be more sea between or near the tropics; while on the contrary, so often as the above conditions are reversed, the heat will be greater. If this be admitted, it will follow as a corollary, that unless the superficial inequalities of the

earth be fixed and permanent, there must be never-ending fluctuations in the mean temperature of every zone; and the climate of one area can no more be a type of every other, than is one of our four seasons of all the rest."

Lyell goes on to describe the "position of land and sea which might produce the most extreme of cold of which the earth's surface is susceptible", and concludes that if the continents were grouped about the equator the extreme of heat would be experienced, whereas if they were grouped about the poles the extreme of cold would be attained.

There is nothing in Lyell's writings to lead us to suppose that he thought that the continents were ever grouped in this way. He assumes such an arrangement as an extreme case to show that his theory will hold even then; and he clearly recognizes the fact that even comparatively small changes in the distribution of the land would considerably affect the climate.

James Geikie,[1] discussing Lyell's theory, says, "But we are assured that no such distribution of land and water as Lyell thought necessary for the production of our Glacial Period ever obtained in Pleistocene times. We have no reason to doubt that the positions of land and sea were practically the same as they are now." But the view is now gaining ground that the changes in the distribution of land and sea which are known to have occurred in Pleistocene times were sufficient to affect the temperature appreciably.

Croll[2] also dissented from Lyell's theory. He says, "The only other theory on the subject worthy of notice is that of Sir Charles Lyell. These extraordinary changes of climate are, according to his theory, attributed to differences in the distribution of land and water . . . It will be shown in subsequent chapters that this theory does not duly take into account the prodigious influence exerted on climate by means of the heat conveyed from equatorial to temperate and polar regions by means of ocean currents." Lyell did not go to the lengths Croll did on this subject; but that he was quite well aware of it and considered it the following remarks of Lyell show: "The general climate of Europe is materially affected by the volume of warmer water thus borne northwards; for it maintains an open sea free from ice in the meridian of East Greenland and Spitzbergen."

Mr. C. E. P. Brooks[3] has recently devised an empirical method of calculating the probable alteration in the temperature that might be expected from known geographical changes in the outline of the continent of Europe during late geological times, and he considers that they were sufficiently great to cause the Glacial Period. However, he recognizes that such changes could not account for the four great cold periods of the Pleistocene we are now coming to recognize. He suggests that the weight of the ice slowly weighed down the land until the new geographical conditions thus introduced caused the ice to disappear and the climate to ameliorate. On the

[1] *The Great Ice Age*, 3rd ed., p. 792.

[2] *Climate and Time*, p. 8.

[3] Quart. Journ. Roy. Met. Soc., vol. xliii, pp. 159–73, and vol. xliv, pp. 253–70.

disappearance of the ice the land again slowly rose, reintroducing glacial conditions. This is supposed to have taken place four times in succession, each succeeding cold period being less severe than the last.

In Europe there may appear to be some evidence in favour of the view that the periods became less cold as they succeeded each other; but in America there is little evidence of this kind. In Europe during the first cold period the Straits of Dover probably did not exist and the ice advanced over the area now occupied by the North Sea. The opening of the straits at a later period much restricted the advance of subsequent ice-sheets.

I have suggested that the Glacial Period was the result of two agencies acting together. Separately they could not produce the required conditions; but jointly they could. It is well known that the great polar cyclones of the earth are acting in direct opposition to the gradient of temperature on the earth's surface, and produce the poleward flow of the air in temperate regions.[1] The energy which keeps these cyclones in action is very probably cosmical and may undergo periodic fluctuations. In pre-Tertiary times the distribution of land was seldom such as to lower the temperature sufficiently to enable a temporary decrease in the strength of the polar cyclones to produce a glacial period. In Pleistocene times, however, the polar areas became so continental or landlocked that the periodic waning and strengthening of the polar cyclones led to alternating cold and warm periods.

Winds from the Poles towards the Equator do blow, of course, but they are not anticyclonic. They are merely surface winds, or winds resulting from travelling cyclones. The great cyclonic low-pressure areas of the Poles persist throughout the year.

III.—On the Discovery of a Quartzose Conglomerate at Caldon Low, Staffs.

By J. Wilfrid Jackson, F.G.S., and W. E. Alkins, B.Sc.

During a visit to the limestone quarries at Caldon Low last September we had the good fortune to discover an interesting exposure of a quartzose conglomerate containing numerous fossils. The bed was exposed in a strong joint-face running approximately N.N.W. to S.S.E., at the northern extension of the quarry on the north-west flank of the Low, just beyond the mineral line of the North Staffordshire Railway. The altitude is about 900 feet O.D. The conglomerate apparently extended some little distance to the south-west before the opening of the quarry, as we ascertained that some 20 or 30 yards had been removed in gaining access to the limestone behind. It appears to extend for some distance round the flank of the Low towards the north-east.

In the section exposed the conglomerate did not appear to possess definite bedding in its lower portion; but higher up the slope of the hill, on the S.S.E. side of the section, it was seen to pass upwards

[1] *Phil. Mag.*, vol. xxx, pp. 13–33, July, 1915; vol. xxxi, p. 399, April, 1916; vol. xxxv, pp. 221–36, March, 1918.

into thinly-bedded impure limestones with arenaceous layers and lenticular beds of quartz-pebbles, dipping N.N.W. at an angle of 30°. Strong joints, at right-angles to these inclined beds, extended downwards into the more massive conglomerate.

The condition of the section rendered the relation of the conglomerate and upper inclined beds to the massive light-grey limestones (*Productus humerosus*-beds) of Caldon Low somewhat doubtful. On the S.S.E side the conglomerate and inclined beds appeared to overstep the truncated ends of the *Humerosus*-beds (which exhibited little or no dip), thus suggesting an unconformity or a fault. At the opposite end of the section some inclined grey limestones, in part crinoidal, had been left as a low ridge running approximately W.S.W. to E.N.E., i.e at right-angles to the conglomerate section. These beds formed a small anticline near the conglomerate, and may dip under it to the E.N.E.; but this is not certain. The relationship of these beds to the *Humerosus*-beds could not be ascertained owing to the intervention of the quarry-platform.

Judging from the specimens obtained the conglomerate appears to consist mainly of water-worn pebbles of vein-quartz and quartzite, about the size of hazel-nuts: many of these are green-coated. Mixed with them are small pebbles of red jasper, black limestone, chert, light-buff micaceous sandstone, purple volcanic ashes and tuffs, etc., together with water-worn fragments of grey compact limestone, sometimes of large size, the whole being cemented together by a calcareous matrix.

Numerous fossils, chiefly Brachiopods, were obtained from the blocks of conglomerate lying in the quarry. The matrix in and around these has a structure resembling oatmeal. Pebbles of limestone, vein-quartz, fine grey oolite, and other rocks, are also present. The peculiar "oatmeal" type of matrix is particularly striking, and in section the structure is not unlike that of the penecontemporaneously brecciated limestones figured by Professor S. H. Reynolds and Dr. A. Vaughan from the Upper *Seminula*-zone (S_2) of Burrington Coombe.[1]

The original source of the various pebbles is not easy to determine. The fragments of grey compact limestones are undoubtedly of Lower Carboniferous age, and the fact that they consist mostly of fairly large pieces suggests that they had not travelled very far. The black limestone, grey oolite, and chert, are also of Lower Carboniferous age; these, however, are smaller and more worn, and may have come from a greater distance. With regard to the vein-quartz, quartzite, volcanic tuffs, ashes, etc., nothing very definite can be said until further study and comparisons are made. The pebbles of this series are well-rounded by wave-action, the majority being no bigger than hazel-nuts. The included fossils comprise an interesting series. They are mostly in the form of casts, but several still retain the greater part of the shell. In most cases only single valves are present. The imperfect state of preservation of some specimens renders precise identification rather difficult, but careful comparison with examples in our own collections and with figures

[1] Q.J.G.S., vol. lxvii, pl. xxviii, figs. 3 and 4, 1911.

in Davidson's monograph,[1] and in the various papers on the sequence of the Carboniferous Limestone in the British Isles, has enabled us to identify most of the forms. The full list of species, with references, is as follows:—

BRACHIOPODA.

Orbiculoidea sp.
Dielasma hastatum (Sow.). Large form.
Seminula ambigua (Sow.)? Dav., pl. xv, fig. 16.
Athyris cf. *expansa* (Phil.). Cf. Dav., pl. xvii, figs. 3, 3*a*.
Martinia cf. *glabra* (Mart.). Dav., pl. xiii, fig. 8.
M. ovalis (Phil.). Dav., pl. ix, fig. 21.
Spirifer bisulcatus (Sow.). Dav., pl. vi, figs. 6–9.
S. semicircularis (Phil.). Dav., pl. vi, figs. 1–5.
S. aff. *grandicostatus*, M'Coy. Dav., pl. viii, fig. 8.
"*Rhynchonella*" cf. *carringtoniana*, Dav. Dav., pl. xxiii, figs. 22–2*b*; pl. liii, figs. 1, 2.
Orthotetes cf. *crenistria* (Phil.).
Rhipidomella michelini (L'Eveillé). Dav., pl. xxx, fig. 7.
Schizophoria resupinata (Mart.). Large forms.
Productus corrugato-hemisphericus. Including forms like *P. cora*, D'Orb., Dav., mut. D_1 of Vaughan, in Q.J.G.S., 1905, pl. xxv, figs. 4*a*, *b*.
P. cf. *giganteus*, Dav. (*non* Mart.). Dav., pl. xl, fig. 3.
P. longispinus, Sow.
P. concinnus, Sow. Cf. mut. D_2 of Sibly, Q.J.G.S., 1906, pl. xxxiii, figs. 3*a*, *b*.
P. martini, Sow. Dav., pl. xliii, figs. 7, 7*a*.
P. cf. *pyxidiformis*, De Kon. Dav., pl. xlii, fig. 4.
P. cf. *fimbriatus*, Sow. Narrow convex forms like Dav., pl. xxxiii, fig. 14*c*.
P. fimbriato-pustulosus.
P. punctatus (Mart.). Dav., pl. xliv, fig. 14.
P. cf. *aculeatus* (Mart.). Dav., pl. xxxiii, fig. 19.
P. cf. *margaritaceus* (Phil.). Strongly convex forms near Dav., pl. xliv, figs. 5, 5*a*.

OTHER GROUPS.

Phillipsia sp. Pygidium.
Leiopteria sp.
Bellerophon sp.
Phanerotinus cf. *nudus* (Sow.).
Fish-tooth. Cf. *Psephodus magnus*.

Near the top of the section a small, much-weathered, coral of Zaphrentoid type was noticed, but it was impossible to extract it without considerable damage.

The general faunal assemblage would seem to suggest that the forms represented belong to some of the higher beds of the Carboniferous Limestone sequence. As in the case of the pebbles these may all be derived. Comparing the above list with the faunal lists given by Dr. T. F. Sibly for the Carboniferous Limestone of the Midland area,[2] it will be seen that a number of species are identical, more especially perhaps with those listed for the subzone of *Lonsdalia floriformis* = D_2.

Highly fossiliferous white limestones without a trace of any pebbles or extraneous material occur in the churchyard at the

[1] Brit. Foss. Brachiopoda, Part V: The Carboniferous Brachiopoda. Pal. Soc., Lond., 1858–63.
[2] Q.J.G.S., vol. lxiv, pp. 42 et seq., 1908.

adjacent village of Cauldon, some 300 yards to the north of the conglomerate section. These beds resemble the "Brachiopod-beds" of Treak Cliff and Peakshill, west of Castleton, Park Hill, north of Longnor, and other places in the Midland area, and contain much the same fauna. Unfortunately there are no good exposures of these beds, the material collected by one of us (W. E. A.) over a period of two or three years having been obtained mainly from grave-shafts in the churchyard and from a small exposure in a field on the south side.

According to the 1 inch Geological Survey Map (72 N.E.) the limestone here is cut off from the Pendleside Series by faults on the north-west and north-east sides, but no faults are shown on the south, or Caldon Low, side.

Another somewhat similar exposure of highly fossiliferous limestones occurs off the main road, opposite the Red Lion Inn, about half a mile south of the conglomerate section.

The close proximity of a conglomerate to highly fossiliferous pure limestones recalls similar features elsewhere in the Midland area, especially in the neighbourhood of Castleton. A rolled-shell and limestone-pebble conglomerate has long been known in the latter area, and seems to lie at, or near, the top of the *Lonsdalia*-subzone $= D_2$. It is well seen on the eastern side of Cave Dale, Castleton, immediately above the limestone bluffs, beyond the second mineral vein (Faucet Rake?). The dip of the beds here is 30° N.N.W., and in addition to worn and fragmentary valves of *Productus "giganteus"* the conglomerate contains rounded pebbles of limestone, nodules of oolitic chert, and fragmentary corals. An imperfect tooth of *Petalodus* was also obtained here by one of the writers (J. W. J.). A further exposure of the conglomerate is seen at the foot of Cow Low, west of Castleton village. Here the beds dip at 15° N.W., and consist principally of abundant water-worn and rolled shells of *Productus "giganteus"*. It extends westwards to the entrance to the Winnatts, near the Speedwell Mine, and is again seen in a quarry at the foot of Treak Cliff, where the beds dip at an angle of about 20° N.N.E. The conglomerate here contains much crinoid debris, large Productids, *Spirifer bisulcatus*, etc., and in the succeeding flaggy limestones (also in part conglomeratic) numerous fish-teeth, especially *Petalodus*, and the spines and plates of *Archæocidaris*, are to be found. The conglomerate is apparently cut off from the famous "Brachiopod-beds" of Treak Cliff by a fault running N.N.W. to S.S.E. from the Odin Mine to the Winnatts. It reappears, however, near Windy Knoll, where limestone pebbles and oolitic grains form a prominent feature; chert is also associated with it, as at Cave Dale.

Similar conglomerates are to be seen at Barmoor Quarry, near Sparrowpit, and at Glutton Dale, north of Longnor. Along with the shell-debris (*Spirifer bisulcatus*, etc.) and fish-teeth (*Psammodus*, *Psephodus*, *Petalodus*, etc.) at the Sparrowpit locality, a fairly large amount of quartz of a well-rounded character is said to occur.[1]

[1] Trans. Manchester Geol. Soc., vol. xxv, p. 125, 1896.

The only record of a rolled-shell conglomerate on the eastern side of the limestone massif appears to be that of Cracknowl quarry, near Hassop Station.[1]

It is interesting to note that Dr. Sibly[2] and Mr. C. B. Wedd[3] have described sections in the eastern part of the Midland area which afford evidence of local earth-movement and erosion in Upper Carboniferous Limestone times. One section is near Youlgreave, the other at Darley Bridge. The limestones in these sections are regarded as representing a high level in the *Lonsdalia*-subzone, and in both cases black shales, presumably of Pendleside age, clearly overstep their denuded edges, thus causing local unconformity. It is not improbable that the formation of the shell and limestone-pebble conglomerate of Castleton and other places was contemporaneous with the earth-movement and erosion which produced these unconformities.

In addition to the main unconformity near Youlgreave, Dr. Sibly also points out the probability of further contemporaneous elevation and erosion during the formation of the Upper *Lonsdalia*-beds, as in the lower part of the section the truncated edges of a series of limestone-beds form a surface upon which rests another series of beds, less steeply inclined.

In the North Wales sequence Dr. Wheelton Hind and Mr. J. T. Stobbs have described a similar phenomenon to that of Youlgreave in the upper beds of the Carboniferous Limestone seen in Waenbrodlas Quarry, Halkyn Mountain (Flintshire).[4] At or about the same horizon (D_2) in other localities in North Wales the same authors record the occurrence of a conglomerate with quartz-pebbles succeeding a *Productus giganteus*-bed.

The absence of sections at Cauldon renders it difficult to ascertain the relationship of the quartzose conglomerate to the limestones containing a fauna typical of the Brachiopod-beds of Castleton. Consequently, at the moment, it is not possible to correlate with absolute certainty this conglomerate with that of Castleton and other places. The contained fauna seems to suggest that it may be contemporaneous, and if so there appears to be a considerable gap between it and the *Humerosus*-beds of Caldon Low. The age of the latter beds is a subject upon which some difference of opinion prevails. Dr. Sibly, in 1908,[5] regarded them as probably belonging to the upper part of D_1, while others, including Dr. Wheelton Hind, are inclined to place them much lower in the sequence, viz. C–S_1.[6] In this connexion it will be of some interest to record the discovery by one of the writers (J. W. J.) of an interesting coral recently in

[1] Elizabeth Dale, *The Scenery and Geology of the Peak of Derbyshire*, 1960, p. 17.

[2] Op. cit., 1908, p. 63, and fig. 5 (p. 62).

[3] Discussion of Dr. Sibly's paper, op. cit., p. 81, and Mem. Geol. Surv., *The Geology of the Northern Part of the Derbyshire Coalfield and Bordering Tracts*, London, 1913, p. 35.

[4] Geol. Mag., N.S., Dec. V, Vol. III, p. 396, Pl. XXII, 1906.

[5] Q.J.G.S., vol. lxiv, p. 44, 1908.

[6] Geol. Mag., Dec. VI, Vol. V, p. 480, October, 1918.

these beds. This may prove of some assistance in arriving at the precise age of the limestones in question. The specimen, which is unfortunately rather imperfect, was obtained from a large block of limestone in a quarry worked for road-metal on the western side of the Low, midway between the Red Lion Inn and Cauldon village. Other blocks in this quarry contained numbers of *Chonetes* cf. *comoides*, *Bellerophon*, and *Productus humerosus* (*P. sublævis*) of two forms—one strongly convex and narrow with a broad shallow depression down the centre of the back;[1] the other broader and flatter with a similar depression down the back, from which later on a low central ridge bearing spine-bases arises: these spine-bases are also visible on the umbonal portion of the depression, and on the ears.[2]

The coral, which consists almost entirely of the calix, is distinctly Caninoid in character, and measures about 32 mm. in diameter. It is apparently closely related to *Caninia cylindrica*, mut. S_1, as figured by Dr. Vaughan in 1905.[3]

Regarding *Productus humerosus* (= *sublævis*) Dr. Vaughan states[4] that in the Franco-Belgian area an early smooth form occurs at the top of C_2. In the South-Western Province this form is very rare, but is recorded from the C_2-oolite of Burrington. In the Clitheroe region this early form enters at the top of C_1 and forms a persistent band at the top of C_2 (as in Belgium). *Productus* cf. *sublævis* is also recorded from the Lane Limestone (co. Dublin) = C_1. This limestone underlies the Lane Conglomerate = C_2, and both were formerly regarded as D.[5] Most of the Caldon examples we have seen agree closely with Vaughan's figure of the early form from the Franco-Belgian area,[6] and with a specimen from Twiston, Lancs, in the collection of one of the writers (J. W. J.); but there is the broader spinous form to be considered.

It is unfortunate that more definite conclusions cannot be given as to the age of the quartzose conglomerate and its relation to the *Humerosus*-beds of Caldon; but we are hoping that, in the near future, quarrying operations will expose further sections which will provide us with more conclusive evidence.

The material dealt with in this paper will be deposited for future reference in the Manchester Museum.

[1] Cf. Q.J.G.S., vol. lxxi, pl. vii, fig. 8, September, 1915.

[2] Cf. Davidson, Monograph, pl. li, figs. 1, 2. The original of fig. 2 is stated by Davidson, p. 234, to have been found at Caldon Low.

[3] Q.J.G.S., vol. lxi, pl. xxiii, fig. 1*a*, 1905.

[4] Q.J.G.S., vol. lxxi, p. 47, 1915.

[5] L. B. Smyth, Scient. Proc. Roy. Dublin Soc., N.S., vol. xiv, No. 41, August, 1915.

[6] Q.J.G.S., vol. lxxi, pl. vii, fig. 8, 1915.

IV.—Notes on Ammonites.

By L. F. Spath, B.Sc., F.G.S.

(*Continued from p. 35.*)

II.

Obliquity of the Suture-line.

A CHARACTER of the suture-line that has received considerable attention lately is the obliquity with regard to the radius. Of course, it had long been noticed that suture-lines may vary in the form and foliation of their elements (brachyphyllic, dolichophyllic, and leptophyllic suture-lines of Mojsisovics,[1] and euryphyllian and stenophyllian suture-lines of Haug[2]) as in their general course. There may be (externally) a strong convexity forward (*Cyclolobus*), a straight (*Sphenodiscus*) or wavy line (*Pseudosageceras*), or a convexity backward (*Protengonoceras*). Again, the suture-line may be inclined strongly forward towards the umbilicus (*Cheltonia*) or have a retracted or dependent inner portion (*Psiloceras*). It is this latter obliquity that has been used as a generic and even family distinction, e.g. by Mr. Buckman,[3] to determine the affinity of *Bredya* with Hammatoceratidæ, and not Hildoceratidæ.

On a previous occasion[4] when dealing with the "suspensive lobe" (dependent auxiliaries) of *Psiloceras* and its ancestors, the writer expressed the opinion that its significance was doubtful. Since then the dissection of a number of Ammonites showing this obliquity of the suture-line towards the umbilicus, e.g. Derocerates, and the developing of the whole of their external and internal suture-lines has confirmed his belief in the impossibility of using this variable character—like the above-mentioned divisions proposed by Mojsisovics and Haug—even for generic distinctions.

Mr. Buckman, in his Monograph of the Inferior Oolite Ammonites,[5] figures on pl. A, fig. 29, the suture-line of a *Hildoceras* that has a strongly ascending inner portion as compared with the type given in fig. 28. Waehner[6] has shown that dependent auxiliaries are neither always present in *Psiloceras*, nor always absent in *Arietites*. Tornquist[7] figures suture-lines of *Pictoniæ* that show the typical descent towards the umbilicus and others that are straight. And it may be recalled here what R. Douvillé[8] says concerning the genus *Macrocephalites*: "As regards the more or less great obliquity of the

[1] "Die Cephal. d. Hallstätter Kalke": Abh. k.k. Reichsanst., vol. vi, p. 2, 1873–93.

[2] "Les Amm. du Permien et du Trias": Bull. Soc. Géol. France, ser. III, vol. xxii, p. 409, 1894.

[3] "Certain Jurassic (Lias-Oolite) Strata of South Dorset; and their Correlation": Q.J.G.S., vol. lxvi, pp. 97–8, 1910.

[4] "Development of *Tragophylloceras Loscombi*": Q.J.G.S., p. 352, 1914.

[5] Pal. Soc., vol. i, 1887–1907.

[6] "Beitr. Kenntn. Tief. Zonen Unt. Lias Nordöstl. Alpen": Beitr. Geol. Pal. Österr.-Ung., vol. iv, pts. iii, iv, pp. 190–202.

[7] "Die Degenerierten Perisphinctiden des Kimmeridge von Le Havre": Abh. Schweiz. Pal. Ges., vol. xxiii, p. 41.

[8] "Etude sur les Cardioceratidés de Dives, etc.": Mem. No. 45 Soc. Géol. France, Pal. i, 19, fasc. ii, p. 14.

suture-line in relation to the radius, it seems to vary with time in the whole group, as has recently been shown by Lemoine (1910). The same thing is noticed in *Pachyceras* and *Tornquistes*, where the most recent forms have the most inverse suture-lines. We have to do here, therefore, rather with a general phenomenon, appearing in a parallel manner in the different branches of a given family, or even in fairly distant groups, than with a special character peculiar to a single branch, and permitting us, consequently, to follow it through time. In this connexion it may be called to mind that in quite another group of Ammonites, in *Simbirskites* of the Lower Cretaceous, identical and exactly contemporaneous forms may have either a normal or a freely inverse suture-line (*S. inversus* and *subinversus*). It does not seem, therefore, that this character of an oblique suture-line has very great importance."

It might be thought that the character of the umbilical edge or slope, and its ornament, could affect the position of the auxiliaries, but the evidence in favour of this is not satisfactory. One should not find in identical smooth oxycones, with an exactly similar, rounded, umbilical edge, suture-lines that may be either concave forwards or convex, either rising or descending towards the umbilicus. But in, e.g., *Cheltonia*, the extremely oblique and almost tangential suture-line of the sides is compensated for by a very deep internal lobe, and the variation in the course of the suture-line does not appear to affect the convexity of the septum as a whole. It may be recalled here that the deposition of calcium-carbonate, as in the recent *Nautilus*, probably began at the sides of the shell, i.e. in the region farthest removed from the siphuncle, so that dependent auxiliaries near the umbilicus suggest less penetration posteriorly of the attaching fibres of the lobes. Swinnerton & Trueman (p. 36) give two interesting illustrations of incomplete septa in *Dactylioceras* and *Polymorphites*. They show that the septa were indicated in all sutural details, and though only formed in part were situated at the normal distance from the preceding septa.

The functions of the septal edge are not impaired by the variation of its course or curvature, therefore, and the comparative insignificance of the obliquity is realized when the external and internal[1] suture-line is considered as one whole. That in a *Lioceras*[2] direction and curvature may vary within the same species, and that in *Psiloceras*[3] even in the same individual, first a complex suture-line with dependent inner lobes, and at the end a simple one with ascending

[1] The presence of a high internal saddle in certain Japanese *Scaphites* induced Yabe ("Die Scaphiten a. d. Oberkreide von Hokkaido": Beitr. Pal. Österr.-Ung., etc., vol. xxiii, p. 167, 1910) to create a new genus, *Yezoites*; but the writer would agree with Nowak (in "Untersuchungen ü. Cephal. Ob. Kreide in Polen", ii, Die Skaphiten: Extr. Bull. Acad. Sci. Cracovie, July, 1911, p. 549), who cannot admit that the internal portion of the suture-line of Ammonites is the most important as regards the determination of their relations, though "it must not be underestimated or, still less, neglected, as is still done very often at the present day".

[2] Horn, "Die Harpoceraten der Murchisonæ-Schichten des Donau-Rhein-Zuges": Mitt. Grossh. Bad. Geol. Land. Anst., vol. vi, pt. i, p. 264.

[3] Neumayr, "Kenntn. Fauna Unterst. Lias i. Nordalpen": Abh. k.k. Reichsanst., vol. vii, pt. v, p. 25, pl. iv, figs. 6*a*, *b*, 1879.

auxiliaries may be found, shows the unimportance of this character for classificatory purposes, even if, occasionally, it be constant in a group of forms.

Workers on Ammonites recognize that the details of the suture-line may vary greatly in a given species. Noetling,[1] e.g., in his research on the suture-line of *Pseudosageceras multilobatum*, examined many specimens, but found no two suture-lines alike. On pl. xxvii, e.g., he figures forty-eight suture-lines, arranged in six groups, and showing a great variability both in the ventral and in the first lateral lobes. Pompeckj[2] thinks that *Oxynoticeras oxynotum* presents as many varieties. On the other hand, the writer[3] found that the suture-line of young specimens of *Tragophylloceras Loscombi* was very constant, and that the only variability noticed was in relation to the degree of complication at a given size; whereas in larger examples, again, no two suture-lines were exactly alike. This only confirms that the development of the suture-line should be studied, from its first, angustisellate beginning, and when this, in conjunction with the development of all the other features of the shell, is used as a basis for classification, variability within a species will prove no obstacle.

That in Phylloceratidæ and Lytoceratidæ neither this variability and obliquity, nor the features of instability already referred to, are apparent, seems to the writer of some significance.

Spacing of the Septa.

Hyatt stated[4] that the septa "vary exceedingly in number among different species and also at different ages of the same individual, but they are tolerably constant, as a rule, within the limits of one and the same species, if specimens of the same age are compared. They follow one another in regular succession, but, as observed by Hyatt, the intervals are relatively greater in the young, more constant in the adult, and then markedly decrease in the oldest stage of development". Bather, before Hyatt, had been more definite, and stated that the "radio of the normal septal intervals was constant in any given shell, while the approximation of the last septa was a geratologous character".[5] Blake[6] remarked with regard to the latter statement that "if any law could be founded on this and applied to phylogeny, we should not find the ratio of the second chamber to the first so variable as Barrande has shown it to be, nor should we find approximate septa in the early *Orthocerata*, nor crowded sutures in Ammonites at their acme".

Both in *Nautili* and in Ammonoids there are many irregularities in the spacing of the septa. Mr. Crick[7] mentioned "two *Nautili*

[1] *Palæontographica*, vol. li, pts. v, vi, p. 259, 1905.

[2] "Notes sur les *Oxynoticeras* du Sinémur. Supér. du Portugal, etc.": Comm. Serv. Geol. Portug., vol. vi, pt. ii, p. 219, 1906.

[3] Op. cit., 1914, p. 346. [4] Op. cit., i, p. 510, 1900.

[5] "The Growth of the Cephalopod Shells": Geol. Mag., Dec. III, Vol. IV, pp. 446–9, October, 1887; and "Shell-growth in Cephalopoda (Siphonopoda)": Ann. Mag. Nat. Hist., ser. vi, vol. i, pp. 298–310, April, 1888.

[6] "The Evolution and Classification of the Cephalopoda, an Account of Recent Advances": Proc. Geol. Assoc., vol. xii, p. 291, 1892.

[7] Proc. Geol. Soc., No. 979, p. 3, November 11, 1915.

from the Upper Cretaceous Rocks of Zulūland. Each showed approximation of the last three septa . . . One specimen showed also irregularities of depth in the other chambers of the camerated part of the shell". Foord[1] figures two Inferior Oolite *Nautili* (*N. pseudolineatus* and *N. polygonalis*), one of which has the last septum closer than the usual interval, the other has it more distant. A fair amount of variability as regards the spacing of the septa (especially the last) is also found in Palæozoic genera, e.g. the Middle Devonian forms referred to "*Gomphoceras*" by Cleland.[2] In Wisconsin this genus is found not only in great abundance as regards the number of individuals, but is also represented by a variety of more or less closely related species, which rather suggests favourable conditions. In Bohemia also, where the Silurian period produced an exceedingly rich Cephalapod fauna, this variability prevails, as is shown in Barrande's classical work.[3]

As regards Ammonites, the irregularity is even more striking. A. E. Trueman[4] has recently figured some *Polymorphites* that show approximation of the last septa. This seems to be an unstable genus of generally small and very variable forms of limited horizontal distribution. But in *Hildoceras bifrons*, which species-group, with horizontal variants and vertical mutations, is found in North-Western Europe, in the Alpine-Mediterranean-Pontian province, and as far as Japan, the phenomenon is observed, as well as in its probably benthonic and often one-sided derivative *Frechiella*. Among fifty-six specimens of *Amioceras niger* (Blake), i.e. of another universal genus, that the writer examined, six specimens had their suture-lines fairly distant, and in five more the distance was somewhat less. Twenty-seven specimens had the septa a medium distance apart; in five they were fairly close, and in thirteen very close together. Besides, there were irregularities in almost every specimen, many of them showing closer septation after a fairly distant beginning.

On thirty-one specimens the last sutures were well displayed, and here even greater irregularity was noticed. In one specimen there was no approximation at all, and in two more it was only just noticeable. Nine specimens had the last two suture-lines fairly close, in three more they were very close. In eight specimens there was approximation of the last three septa; in one the last four suture-lines were fairly close, and in another they were very close together. One specimen had the last five septa closer than the previous ones, but they were equidistant from one another, whereas in another specimen the last five septa were gradually approximating. Two more specimens had the last six suture-lines gradually getting closer, and finally, in another two there was first

[1] Op. cit., vol. ii, p. 214.

[2] "The Fossils and Stratigraphy of the Middle Devonic of Wisconsin": Wisc. Geol. and Nat. Hist. Surv., Bulletin No. xxi, 6, 1911.

[3] *Système Silurien de la Bohème*, vol. iii (Cephal.), 1867–77.

[4] "Observations on the genus *Polymorphites*": GEOL. MAG., N.S., Dec. VI, Vol. IV, pp. 443–4, figs. 1, 11, October, 1917. The writer cannot accept the derivation of this genus from the much earlier arietid *Agassiceras* development, *Cymbites*, and will refer later to the resemblance in the sutural development.

approximation, then wide intervals, and approximation again of the last two septa.

Amioceras nodulosum (J. Buckman) presents a similar variability, to judge by nineteen specimens examined. Among twenty-one specimens of *Peltoceras* aff. *Eugenii* (Raspail) there were seven that showed no approximation at all, and the majority of the remainder had only the last septum slightly closer. In only two specimens they were very close, and only one had the last three septa gradually approximating. In three specimens the distance between the third and second septum from the end was greater than that between either the fourth and third or between the second and the last. It was also noticed that in two specimens the last suture-lines (in both cases only slightly approximating) were much fainter than the others, indicating a thinner septum instead of a thickening as in the case of the *Nautili* mentioned, or else the beginning of deposition of calcium-salts on a conchiolin-membrane as noticed by Swinnerton & Trueman.

Again, R. Douvillé[1] found a great variability in the spacing of the septa in *Quenstedticeras lamberti*, and he figures two specimens which are very different in this respect. Douvillé adds: "As I have observed that in many dwarfed and œcotraustic forms, (which are in all probability the males, *Chapuisi*, etc.) the septa are always extremely close, it seems to me that one could see a certain connexion between small size and close septa. The *Quenstedticeras* with close septa would never have obtained great dimensions, and would be the males, and vice versa. Unfortunately there are too many transitions among the various distances of the septa to enable one to think of demonstrating this hypothesis. But it also does not disprove the theory, for if the spacing of the septa be a secondary sexual character in *Quenstedticeras*, it is possible that it may be very unequally developed in the individuals of the two sexes."

It seems to the writer that with regard to sexual dimorphism in Ammonites, the evidence to-day is as unsatisfactory as it was when Buckman and Bather inquired into this problem, and came to the conclusion that "sexual dimorphism had yet to be proved".[2] The two Ammonites figured by Douvillé differ, however, e.g., in the width of the umbilicus, and in the writer's specimens of *Arnioceras* the suture-lines were by no means all alike, so that it might be suggested that they represent several types, perhaps due to hybridization of the extreme members. As all my specimens of *Arnioceras niger* came out of one block it cannot be a question of different surroundings. Slight differences in the character and thickness of the shell or of the septa, and the simplification of the edges of the latter, might account for the variability in individuals of the same species; but rate and arrest of growth would differ especially if either the stock itself or the environment were unstable. What Edwards[3] said with regard to the London Clay *Nautili* may be

[1] Op. cit. (Cardioceratidés), p. 61, fig. 60.

[2] "Can the Sexes in Ammonites be distinguished?": Nat. Sci., vol. iv, p. 430, June, 1894.

[3] *The Eocene Mollusca*, pt. i: Cephalopoda (Pal. Soc. Mon.), 1849, p. 44.

quoted in this connexion: "The ratio of increase [of the chambers] is apparently uncertain and is influenced probably by the growth of the animal, which would, of course, depend on the supply of food and other circumstances."

Mode of Life.

In this connexion, again, it may be noticed that among Jurassic and Cretaceous Ammonites the long-lived Phylloceratids and Lytoceratids show the greatest constancy of the septal ratio; and their stability is further shown by the infrequency of another feature of the suture-line, namely its asymmetry, which will be considered presently. But since reference to the probably nectonic character of these Phylloceratids and Lytoceratids and certain oxynote shells has been made, it is necessary to insert a few remarks on Hyatt's hypothesis, that the "progressive complication of Ammonite sutures took place because of their utility in helping to carry and balance the shell above the extruded parts when the animal was crawling".[1] That author believed that the complication was directly correlated with the outgrowth of rostra, and stated: "The presence of a rostrum indicates the disuse and disappearance of the swimming organ (hyponome), which in *Nautilus* causes the formation of the hyponomic sinus in the aperture and flexed growth-lines on the venter."

This connexion between the disappearance of the hyponomic sinus (not of the swimming organ) and the complication of the lobe-line seems very doubtful. A form like *Beloceras*, with hyponomic sinus, was probably as much an adaptation to an actively swimming mode of life as later shells of a similar flat and acute-ventered shape, whether they were Nautiloids like *Phacoceras oxystomus* (Phillips) and *Stenopoceras Rouilleri* (de Koninck), or typical Ammonites like *Pinacoceras* or *Aspidoides*. Kerr[2] suggested that "the structure of the infolding edges of the hyponome and the muscular character of this organ would enable the animal to unroll and flatten it out so as to be available for crawling". Thus it would be homologous with the foot of Gasteropods. And as Ammonoids gradually adopted a freely swimming mode of life, the hyponomic sinus disappeared. In *Beloceras* already, it must have lost its original use. Thus there would have been no disappearance of the swimming organ, but the absence of a hyponomic sinus in the later Ammonoids would show that the hyponome was not used for crawling as in typical Nautiloids.

Hyatt also thought that "the shells of Ammonoids, being less bulky in proportion than those of Nautiloids, were correspondingly less buoyant". But it has already been mentioned that *Nautilus* has been found attached to the bottom, whereas some of the least "bulky" of Nautiloids, like the above-mentioned *Phacoceras* and *Stenopoceras*, were adapted to an actively swimming existence. It is probable that neither the typical Ammonoids and Nautiloids, nor such a radially symmetrical, benthonic structure, as the Devonian "*Gomphoceras*", already referred to, or e.g. a delicate *Carthaginites*

[1] Loc. cit. (in Zittel-Eastman, 1900), p. 544.

[2] "Anatomy of *Nautilus pompilius*": Proc. Zool. Soc., 1895, pp. 664–86 (quoted in Zittel-Eastman, 1900, p. 506).

were cumbered with a very buoyant shell. Solger[1] concluded from the fact that an injury to the chambers and destruction of several septa made no apparent difference to the animal, which continued its growth without noticeable irregularity, that the Ammonite was benthonic before the accident and could not have been a swimmer. But this may only show that the buoyancy did not depend on the air-chambers only; and "bulk" in the case of a sharp-ventered, thin shell, was not necessary to enable its occupant to swim well and quickly. The damage to the earlier whorls of large and evolute shells at a late stage (large Arietids often have no centre like certain perforated *Nautili* of the Palæozoic or Triassic) probably would not have affected the buoyancy of the shell and mode of life of the animal more than the loss of its apex would have affected an *Orthoceras*.

The problem of disposing of superfluous calcium salts was probably never a pressing one in Ammonoids, for as in other tubular organisms growth could generally continue indefinitely whether the cone was coiled or straight, and when a large amount of mineral matter went to elaboration of one feature, the equilibrium was generally maintained. The periodical thickenings of ridges and flares, e.g., which are also found in the long-lived genera *Phylloceras* and *Lytoceras*, cannot in the writer's opinion be looked upon as such deposits of superfluous calcium-carbonate, after the manner of tabulæ, diaphragms, etc., in other tubular organisms,[2] and it must be remembered that very elaborate apertural structures seem to have been resorbed occasionally. A more fundamental problem than the necessity of getting rid of an excess of calcium-salts is presented by *Pinacoceras*, which represents the extreme in sutural elaboration among Ammonoids, and where the septal edge seems to be complicated beyond utility and mechanical requirements, and by the crowding of septa, which also occurs during the Triassic acme of the group. This is probably comparable with the specialization and running to extremes in other directions, e.g., size, ornamentation, or uncoiling, a phenomenon not confined to Ammonoid phylogeny, and generally followed by the extinction of the specialized lineage at or near the height of its career.

V.—Notes on Yunnan Cystidea. III. *Sinocystis* compared with similar genera.

By F. A. Bather, D.Sc., F.R.S.

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A.—Comparison with *Aristocystis*, *Hippocystis* n.g., *Calix*, and *Archegocystis*.

THE Diploporita, to which Order *Sinocystis* clearly belongs, have been divided into Families according to the greater or less extension of the subvective system over the theca and the modifications thus induced in the arrangement of the thecal plates.

[1] "Fossilien d. Mungo-Kreide": Geol. v. Kamerun, ii, p. 216, 1904.

[2] W. D. Lang, "Calcium Carbonate and Evolution in Polyzoa": Geol. Mag., Dec. VI, Vol. III, No. 620, pp. 74–5, February, 1916.

All those in which the epithecal food-grooves do not extend beyond the adoral circlet of plates are referred to the Sphæronidæ. The line between the Sphæronidæ and the more advanced Glyptosphæridæ cannot be drawn rigidly, and such a genus as *Proteocystis* constitutes a natural transition. *Sinocystis*, however, comes well within this boundary.

On the other side it is not easy to define the limit between the Sphæronidæ and the Aristocystidæ, from which, apparently, they were evolved. In 1899 and 1900, accepting the statement (which I was unable to disprove) that the genera referred to the latter Family had no exothecal skeletal processes (e.g. brachioles), and observing the irregular and apparently unspecialized arrangement of their pore-canals when present, I placed the Aristocystidæ in the Amphoridea. Jaekel (1899) removed from the Aristocystidæ all the genera that I was including in that Family, with the exception of *Aristocystis*, but added to it his new genus, *Trematocystis*, which will be discussed in Section B. In 1906 (Palæont. Indica, N.S., II, No. 3) I showed that the pores in *Aristocystis dagon* from Burma were haplopores, that is to say not yoked in couples but isolated and irregularly distributed, and that they might be connected by surface channels which had a radial arrangement and crossed the sutures. Consequently I was not induced to place *Aristocystis* with the Diploporita as Jaekel had done.

Taking *Aristocystis* as represented by its genotype, *A. bohemica*, with which *A. dagon* is in general agreement, one notices a considerable resemblance to *Sinocystis*: the extended peristome and the three other thecal openings occupy the same relative positions and have much the same shape in the two genera. The genera are distinguished by their pores, and by the less development of the brachiole-facets in *Aristocystis*. One would take *Sinocystis* to be derived from *Aristocystis*, but there is the possibility that Jaekel may be right in reversing the relation. Unfortunately there is at present no means of settling this question by reference to stratigraphical position.

It should be remembered that the pore-structures figured by Barrande for various specimens of *Aristocystis* fall into two categories. The pores found in the typical *A. bohemica* seem to be haplopores, united by surface-channels into series ranging from 2 to 6; in this species the channels do not cross the sutures. The channels are of approximately equal width throughout their length, but are sinuous and irregular. In the other category the pores are far more obviously in pairs, and those of each pair are connected by a rather narrow channel of horse-shoe shape, at the ends of which they lie (Barrande, 1887, pl. 13, figs. 4, 12, 13, 15, 18; pl. 17, fig. iii, 5; pl. 14, figs. 10, 11). On quite unimportant grounds of external shape, Barrande included these and other specimens in *A. bohemica* as varieties, but he did also suggest that none of those with horse-shoe channels really belonged to *Aristocystis*. The adoral region of the theca in the latter specimens is unknown, but the pore-character warrants their separation as a genus for which I propose the name *Hippocystis* in allusion to the horse-shoe. It may be left, pending further information, in the Aristocystidæ.

The genotype is *H. subcylindrica* (Barrande sub *Aristocystites?*), and for this the original of Barrande's pl. 13, figs. 1–4, is selected as Holotype. The holotype of *A.? grandiscutum* (Barrande, pl. 17, fig. iii) should be referred to *H. subcylindrica*, and the two other specimens of *A.? grandiscutum* (pl. 14, fig. 20, pl. 38, fig. 30) revert to *A. bohemica*. These specimens were associated by Barrande on account of a similarity in the basal attachment—a character of individual adaptation, insufficient to distinguish them from the species to which they are now referred.

Calix sedgwicki Rouault, which was placed by me in the Aristocystidæ (1900), was, after examination of specimens, referred by Jaekel (1899) to the Sphæronidæ. The adoral region remains unknown, but the structure of the thecal plates shows some resemblance to *Sinocystis yunnanensis*, viz., in the umbonal pustule, and in the frequent radial arrangement of the diplopores on the surrounding area of each plate. Jaekel, as previously mentioned (vol. V, p. 513), believes that the diplopores of *Calix* had a covering of epistereom. Some specimens referred by various authors to *Calix* may belong to *Aristocystis*; *Calix sedgwicki* itself may not be generically separable from *Codiacystis* Jaekel (= *Craterina* Barr. non Bory).

Archegocystis Jaekel, with genotype *A. desiderata* (Barr.), may be mentioned here because Jaekel is uncertain whether the pores are diplopores or haplopores. Though found in the Lower Ordovician (D, 1, γ), it has five facet-bosses, each bearing five or six grooves, each of which presumably was provided with a brachiole as in *Codiacystis*. A hydropore-slit and gonopore are placed as in *Aristocystis*.

B.—Comparison with *Megacystis* (synn. *Holocystites*, *Trematocystis*).

The fossils to which, at first sight, *Sinocystis* bears the strongest resemblance, are undoubtedly those from the Silurian of N. America which for many years passed under the name *Holocystis* (*-ites*). Justifiably, therefore, Dr. Reed alludes to these in his account of *Ovocystis mansuyi*, but to make the resemblances and the differences clear it will be well to go into greater detail.

1. *History of the Genus.*

The fossils referred to were first made known by James Hall, in the form of internal casts from the Niagara Limestone of Racine in Wisconsin (1861, Ann. Rep. Geol. Surv. Wisconsin, p. 23; 1862, Rep. Geol. Wisconsin, I, pp. 69 and 431, text-fig. 16/1 & 2). He published figures but no description, and distinguished two species under the names *Caryocystites cylindricum* (fig. 16/1) and *C. alternatum* (fig. 16/2). In the 20th Report of the New York State Museum, of which the earlier pages seem first to have been issued in 1864, Hall established the new genus *Holocystites* (p. 311) for the reception of these two species as well as the new species *H. abnormis*, from Racine, and *H. winchelli*, *H. scutellatus*, and *H. ovatus* from Waukesha, Wis. The complete Report was issued (presumably in a limited edition) in January, 1865, and (more freely) in 1867; a revised edition was published in 1870. By 1865

Hall had recognized that the name *Holocystis* had been used by Lonsdale in 1849 for a Cretaceous coral; he therefore proposed (1865, p. 380; 1870, p. 429) to replace his own *Holocystites* by *Megacystites*. To clear this matter of nomenclature out of the way at once, it may be mentioned that, though Hall's proposal was entirely overlooked by S. A. Miller, it was adopted by Sven Lovén in editing Angelin's "Iconographia Crinoideorum" (1878), by P. H. Carpenter (1891, J. Linn. Soc., Zool. XXIV, p. 47) and by myself (1900, Treatise on Zoology, p. 47). We have all used the form *Megacystis*, recognizing no difference but that of length and cumbrousness between the ending in *-ites* and those in *-us*, *-a*, or *-is*.

Beyond the general shape and the number of plates, very little could be ascertained by Hall from the material at his disposal. In December, 1865, A. Winchell and O. Marcy (Mem. Boston Soc. Nat. Hist. I, p. 9) described a new species, *C. sphæricus*, from the Niagara [Racine] Limestone of Chicago, and mentioned a fine specimen of *Caryocystites cylindricus*, showing the anus.

The *Megacystis ovalis* of Angelin (1878, p. 30) belongs to the Rhombifera, and his "*M. alternata*, Hall, var." (loc. cit.) is a fragment, supposed from Kinnekulle, which may have belonged to any large elongate Sphæronid of Ordovician age.

It was not till October, 1879, when S. A. Miller (Journ. Cincinnati Soc. Nat. Hist., I, p. 129) began the description of species from the lower part of the Niagara Group in Indiana, that it was possible to form an adequate idea of the genus. Miller continued his descriptions through many years,[1] and raised the number of names for North American species from seven to forty-eight. In 1889 (op. cit.) Miller fixed the genotype as *H. cylindricus* Hall. The original of Hall's figure 16/1 of "*Caryocystites cylindricum*" is the holotype of the species (= pl. xii, fig. 4, and pl. xii*a*, fig. 7, of Hall, 1865–67).

Unfortunately Miller's conceptions of Echinoderm morphology were old-fashioned when he began and underwent no change. In reading his descriptions his use of the following terms must be kept in mind:—

"Ambulacral orifice"	Miller	= mouth or peristome.
"mouth"	,,	= anus or periproct.
"anal aperture"	,,	= hydropore, but may sometimes = gonopore.
"ventral" or "anterior"	,,	= posterior.
"dorsal" or "posterior"	,,	= anterior.
"right" and "left"	,,	= left and right.

A list of the American species, with references, will be found in R. S. Bassler's "Bibliographic Index of American Ordovician and

[1] Dec. 1879. Journ. Cincinnati Soc. Nat. Hist., ii, pp. 104–8.
Jan. 1880. Tom. cit., p. 259.
Dec. 1882. Op. cit., v, p. 223.
1889. *N. Amer. Geol. and Pal.*, pp. 253–5.
1891. Adv. Sheets 17 Rep. Geol. Surv. Indiana, Palæontology, pp. 13–18.
Sept. 1892. Ditto, 18 Rep., pp. 8, 9.
July, 1892. With Faber. Journ. Cincinnati Soc. Nat. Hist., xv, p. 87.
Dec. 1894. With W. F. E. Gurley. Bull. Illinois State Mus., v, pp. 5–8.
Dec. 1895. With W. F. E. Gurley. Op. cit., vii, pp. 84–6.

Silurian Fossils" (1915, Bull. 92 U.S. National Mus.), under *Holocystites*. From the Racine Limestone of Wisconsin and Illinois there are the seven species already mentioned as described in 1864–5, as well as *H. jolietensis* Miller (1882), from Joliet, Ill. From the underlying Laurel Limestone near Waldron, Ind., is *H. pustulosus* Miller (1878). The Osgood Limestone of Indiana, which is slightly older, has yielded specimens in Jefferson county, mostly from Big Creek, near Dupont, but some from the neighbourhood of Madison, and in Ripley county, mostly from near Osgood. On these Miller based forty species.

In time, then, these species are confined to a period extending from the top of the Clinton to the middle of the Lockport, approximately equivalent to the age of the Woolhope Limestone and the lower half of the Wenlock beds. In space they are confined to the south-eastern quarter of Indiana and a strip bordering Lake Michigan on the south-west. That is to say, they inhabited the Indiana Basin of the Mississippian Sea, which derived its fauna, according to Schuchert (1910), from the Atlantic by way of the Gulf of Mexico. The bare record of *H. globosus*, from the Rochester Shale of Hamilton, Ont.,[1] is for the present unsupported by published evidence, but it was just on the border of the same Basin.

2. *Specific Characters in Megacystis.*

Everyone who has alluded to the forty-one species proposed by S. A. Miller (especially P. H. Carpenter, 1891; Jaekel, 1899; R. R. Rowley, 1903) has considered that they might be reduced to a far smaller number. Even Miller himself wrote in 1892: "The Holocystites are so variable in all respects that it is hard to tell exactly what should be considered specific characters and what should be regarded as variations among fossils belonging to the same species."

Here we obtain some guidance from the specimens of *Sinocystis*, which no one could regard as representing more than three species. The size and form of the theca are seen to vary within wide limits, in part no doubt with age, and the absolute number of plates is correlated with the growth of the theca. The positions of the thecal openings are also subject to slight individual variation, possibly connected with the position assumed by the theca. The size and shape of the base depend, as usual, on the surface to which the theca chanced to become attached, and on similar external conditions. There is no doubt a difference of general form between the pear-shaped *S. loczyi*, the more globose *S. yunnanensis*, and the egg-shaped *S. mansuyi*, but this of itself would not enable one to determine the species of such a specimen as I, 10. Slight differences seem to persist in the form of the facets and cover-plates, and some definite character might be deduced from a large series. But the most easily recognized and quite constant differentia lies in the individual thecal plates; these differ in tumidity, but above all in the size, form, and distribution of the diplopores.

Returning to the Holocystites, we find that the pores are just the

[1] W. A. Parks, 1913, Canada Geol. Surv. Guide-book No. 4, p. 132.

characters about which Miller and the other American authors give least information. There is one exception. Under *H. subglobosus*, 1889, Miller says that the pores are in pairs forming figures somewhat like an omega, ω. This striking character was seized on by Jaekel (1899, p. 413) to warrant the separation of this (as genotype) and any similarly constituted species from *Holocystis* (= *Megacystis*) Hall, as a new genus *Trematocystis* with the following diagnosis: [An Aristocystid with] "Theca irregular, oval or pyriform, attached by a rather small surface. Plates fairly large and not very numerous. Apparently as a rule four brachioles at the corners of the peristome. Diplopores with long multifariously irregular pore-passages joined to one another in groups." To this genus Jaekel by implication referred all Miller's species from the Osgood and Laurel Limestones, but possibly he did not mean to include *H. jolietensis* from the Racine Limestone.

The first question to decide is whether this character really distinguished *H. subglobosus* Miller from *M. cylindrica* Hall. Jaekel does not discuss this particular question, but takes the more drastic action of removing all the species referred to the genus by Hall, together with *Saccocystis* [whatever that unknown name may denote], to his Cladocrinoidea [essentially Crinoidea Camerata], of which he regards them as an aberrant type. He gives no reasons for this step, and I have been unable to discover any. The specimens from the Racine Limestone are not preserved so as to show either the smaller thecal openings or the structure of the pores, since they are for the most part internal casts or incomplete external moulds. The surface, however, is said to be strongly granulose, and this agrees with many of the species described by Miller. The specimen from the Racine Limestone of Joliet, described by Miller, is also known from internal casts, but on these Miller detected the marks of pores penetrating the pustules, as in *H. papulosus*. In Hall's figures the pustules are clearly indicated, especially in *H. abnormis*. The later figures of *H. cylindricus* and *H. alternatus* represent the pores as having a radiating arrangement (cf. *S. yunnanensis*). This is also noticeable in Miller's figure of *H. tumidus* from the Osgood Limestone. Therefore there seems no reason to doubt that the American authors are right in associating all these species.[1]

This, however, does not fully answer the question whether all the species have the ω-channels. Owing to the peculiar preservation of the Racine fossils, it is not likely that direct evidence as to the structure of their pores will ever be available. It is legitimate to interpret them in the light of such forms as *H. papulosus*, *H. pustulosus*, and *H. ornatus*, which have plates ornamented with well-marked pustules, usually quite separate from one another. Setting minor differences aside for the present, I may express my conviction that these species, as well as all others from the Osgood Limestone, did possess ω-channels. This conviction is based on the following facts. Miller's silence on the subject, except in the case of *H. subglobosus* (1889), proves only that he attached far less importance to these structures than to the number of plates and the

[1] I do not include Hall's pl. xii, fig. 6, which if correct is almost certainly of a different genus.

shape of the theca; for ω-channels are clearly represented in the drawing of *H. sphæroidalis* Miller & Gurley (1895); the drawings of *H. canneus* Miller (1889), and *H. hammelli* Miller (1889), seem intended to show them; irregular peripores are represented in *H. adipatus* Miller (1891), *H. amplus* Miller (1892), and *H. gyrinus* Miller & Gurley (1894), and seem to have been observed in *H. dyeri* Miller (1879), and possibly *H. ventricosus* Miller (1879). Examination of twenty-seven specimens from the Osgood Limestone of Big Creek, now in the British Museum, show that, whatever the differences of form or surface ornament, all possess or possessed ω-channels. Among these specimens are some determined (rightly or wrongly) by Miller himself as *H. scitulus* (E 16167–8–9) and *H. globosus* (E 16170–1). If Miller did not observe the ω-channels in these and other species, that may be due to the facts that on well-preserved surfaces they are not clearly exposed (E 7673, E 16167), and that on much-weathered surfaces they have often been worn away (E 16171). The reason for this will appear later; for the present I confine myself to the preceding justification of the belief that all Miller's species did have ω-channels, whether he said so or not. This, then, leads to the further conclusion that the species from the Racine Limestone also had ω-channels; at any rate their general resemblance is such that the burden of proof lies on those who would deny this conclusion. Finally it follows that all the American species belong to a single genus, for which Hall's name *Megacystis* (*-ites*) should be adopted.

It may here be suggested that *Allocystites* Miller, 1889, with genotype *A. hammelli*, from the Niagara group of Jefferson co., Ind., is a *Megacystis*. Jaekel (1899, p. 398) placed it in the Sphæronidæ, believing that the pores were diplopores. I would go further, and point out that the drawing of these pores (Miller's fig. 242) indicates the presence of ω-channels. The unique holotype is drawn and described as having a raised margin to the periproct, and the peristome "covered by minute plates forming a pentagonal star". Possibly! but one cannot help doubting whether Miller correctly interpreted these peculiar appearances. There is already a *M. hammelli* (Miller, 1889), probably a synonym of *M. rotunda* (Miller, 1879).

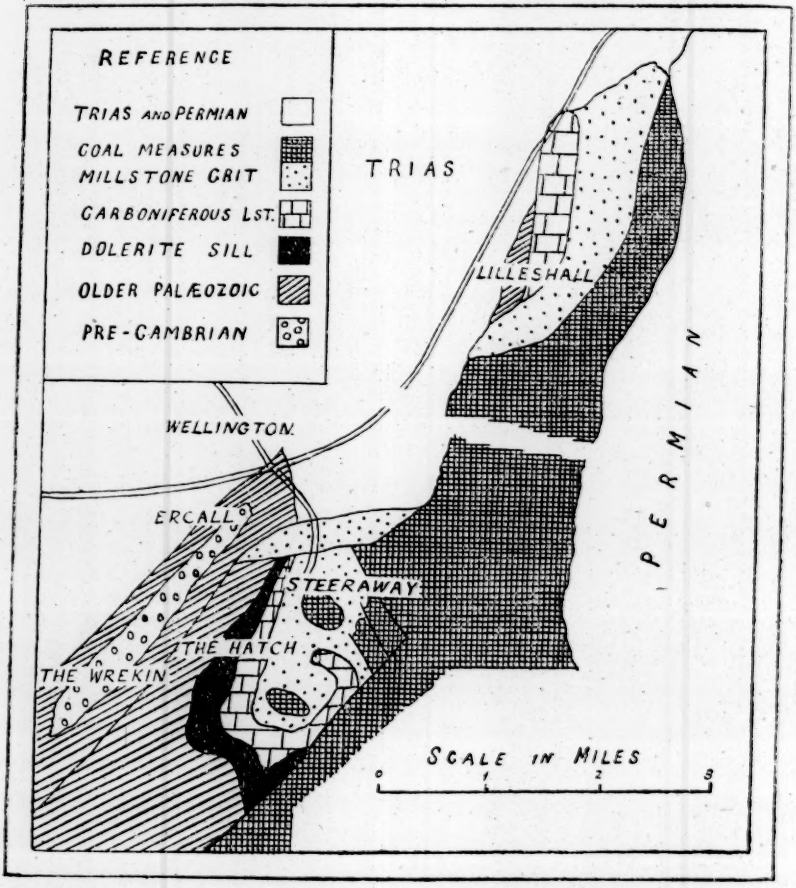
VI.—The Carboniferous Limestone of the Wrekin District.

By L. M. Parsons, M.Sc., D.I.C., F.G.S.

THE Carboniferous Limestone cropping out near Wellington and near Newport in the Wrekin district has hitherto received little attention. One or two references to the Lower Carboniferous rocks of the area are made in *Geology in the Field*, in which the limestone is referred to the *Dibunophyllum* zone,[1] and the intrusive material underlying the limestone is described as an olivine-dolerite, probably of Tertiary age.[2] Apart from these references there does

[1] *Geology in the Field*, p. 762.
[2] Idem, p. 766.

not appear to be any published description of the limestone of the district. Although the Lower Carboniferous outcrops in the area are small, the faunal contents, stratigraphical horizon, and petrology of these rocks are subjects of interest in connection with recent work on the Carboniferous Limestone of various Midland districts.



Sketch-map of the Carboniferous Limestone outcrops near Wellington, Salop. (For the sake of economy of space in map, the Lilleshall outcrop has been brought *nearer* to Wellington; a break in the road and in the mapping of the Trias, Permian, and Coal-measures shows where the intervening space has been omitted.)

Some time ago Professor W. W. Watts suggested that I should examine the limestone near the Wrekin, and I propose to give, in this article, a brief summary of the more important results obtained.

The Lower Carboniferous outcrops of the area occur in two small linear patches, one fringing the hills extending southwards from the Ercall, near Wellington, the other at Lilleshall, near Newport, a few miles further to the north-east.

For the sake of convenience these may be termed the Ercall and the Lilleshall outcrops respectively. Before considering the Carboniferous Limestone in particular, we must note one or two important facts concerning the district in general.

The exact relation of the dolerite sill to the limestone above is now somewhat obscured. The Carboniferous Limestone seen in the area exhibits only a very thin development compared with that of other districts in the Midland Province, and there are no strata corresponding to "Pendleside" beds. The thin local development of "Millstone Grit" is unconformable on the limestone; it rests also upon older formations such as altered Ordovician material near the Ercall. In the neighbourhood of The Hatch, south of Wellington, the Millstone Grit passes up into Coal-measures, though the junction of these formations is often faulted as in the vicinity of Lilleshall.

With regard to the Carboniferous Limestone in particular, it will be as well to consider the two outcrops separately, as there are differences in petrology indicating somewhat different conditions of deposit.

The Ercall Outcrop.

The limestone comes to the surface in a narrow curved belt commencing at Steeraway, a short distance south of Wellington, and extending southwards some distance beyond a place known as "The Hatch". In the immediate vicinity of Steeraway the ground is very much overgrown and only talus heaps mark the sites of former workings. At this locality beds of Millstone Grit are seen, but their relation to the limestone below is obscured. A mineral railway passes from Steeraway southwards through dense woods to The Hatch, where is situated the only good exposure of this outcrop. Here the material is still being worked, and about 20 feet of thinly bedded argillaceous limestones with shaly partings are seen dipping at a small angle to the south-east. The relation of the limestone to either the dolerite below or the Millstone Grit above is again obscured. Petrologically the limestone is interesting on account of the high proportion of argillaceous impurities and the presence of a small amount of magnesium carbonate, which is not sufficient for the formation of dolomite crystals. As far as faunal contents are concerned these beds yield a fair number of specimens, which, however, belong to relatively few genera and species, as the following list shows:—

Faunal List of the Ercall Limestone.

Corals.

Syringopora cf. *geniculata*, Phillips.
S. cf. *reticulata*, Goldfuss.
Alveolites septosa (Fleming).
Lithostrotion junceum (Fleming).
L. irregulare (Phillips).
Diphyphyllum aff. *concinnum*, Lonsdale.
Lonsdalia floriformis (Martin).
Dibunophyllum sp.

Brachiopods.

Athyris planosulcata (Phillips).
Martinia glabra (Martin).
Spirifer planicosta (M'Coy).
S. striatus (Martin).
Productus giganteus (Martin).
P. scabriculus (Martin).
P. longispinus, Sowerby.
P. latissimus, Sowerby.
Chonetes cf. *hardrensis*, Phillips.

This faunal assemblage indicates definitely a D_2 horizon and a fair similarity to the D_2 fauna of the eastern typical facies of the Derbyshire area worked out in detail by Professor T. F. Sibly.[1]

Among the more important points of this similarity is the presence of *Alveolites septosa*, *Lithostrotion junceum*, and *Lonsdalia floriformis* in the coral fauna of both districts. Species of Brachiopods common to the two areas are, *Martinia glabra*, *Spirifer planicosta*, and scabriculate *Producti*.

On the other hand, the rarity of *Dibunophyllum* and the apparent absence from the Wrekin district of other important Derbyshire genera and species must be noted. I have not succeeded in finding either at the Ercall or at Lilleshall the following important corals: *Cyathophyllum regium*, *Campophyllum derbiense*, *Lonsdalia duplicata*, and Zaphrentids. The absence of the last two named has a special significance since they are found in Derbyshire towards the top of the *Lonsdalia* (D_2) sub-zone. It seems reasonable to infer that "Millstone Grit" conditions succeeded those of the Carboniferous Limestone in the Wrekin area during upper D_2 times.

With regard to the Brachiopod fauna, many of the Derbyshire forms, particularly various *Producti*, are absent from the Wrekin development, and another dissimilarity lies in the fact that in Shropshire the corals predominate, whereas in the typical eastern facies of Derbyshire both corals and Brachiopods are well represented.

The Lilleshall Outcrop.

The exposures of limestone seen at Lilleshall are situated at the northern end of the village, where there are one or two disused quarries, mostly overgrown. Examination is largely impeded by water, but in a field near the post office there is a dry exposure. All of these workings show about 25 to 30 feet of red mottled limestone arranged in almost horizontal beds. Unlike the Ercall limestones the Lilleshall material is not very argillaceous and contains little interbedded shale. The most striking feature of the limestone is its highly ferruginous nature. Analyses of this rock give the following average composition:—[2]

	Per cent.
Calcium carbonate	66·8
Iron compounds	28·9
Insoluble residue (silica)	3·8
Traces of magnesium.	
	99·5

Thin sections of this material show that the iron compounds consist mostly of interstitial hæmatite, the introduction of which occurred at a later date, and was probably connected with the Trias which covers the limestone at the northern end of the Lilleshall outcrop. Other points of petrological interest are the absence of dolomite and the presence of glauconite grains.

Palæontologically, the Lilleshall beds are much poorer than those seen at The Hatch. For this reason I give a separate faunal list as follows:—

[1] Q.J.G.S., 1908.

[2] For this and other analyses I am indebted to Mr. H. A. Doy.

FAUNAL LIST OF THE LILLESHALL LIMESTONE.

CORALS.

Syringopora cf. *geniculata*, Phillips. *Lithostrotion junceum* (Fleming).
Alveolites septosa (Fleming). *Lonsdalia floriformis* (Martin).

BRACHIOPODS.

Spirifer planicosta (M'Coy). *Productus giganteus*, Martin.
S. bisulcatus, Sowerby.

This assemblage is sufficient to fix the horizon as being D_2. The remarks given above concerning the absence of *Campophyllum*, *Lonsdalia duplicata*, Zaphrentids, and other Midland genera, are apparently also applicable to the Lilleshall exposures.

SUMMARY OF CONCLUSIONS.

The Carboniferous Limestone of the Wrekin area represents part of the *Lonsdalia* sub-zone of other Midland districts. It has been deposited in shallow water, but without contemporaneous dolomitization, which frequently accompanies shallow-water conditions.

The Millstone Grit came on during upper D_2 times, and there are in the area no deposits similar to either D_3 or Pendleside developments in some other districts.

The fauna of the limestone is in many respects similar to, but in other respects different from, that of the D_2 eastern facies developed in Derbyshire. The limestones of The Hatch, near the Ercall, are of a more normal type than the deposits of Lilleshall, and are, therefore, more reliable as a means of comparison with the Carboniferous Limestone of other areas.

REVIEWS.

I.—THE GEOLOGY OF MANCHESTER AS REVEALED BY BORINGS. By G. HICKLING, D.Sc., F.G.S. Trans. Inst. Min. Eng., vol. liv, pp. 367–417, 1918.

THIS paper gives the results of an investigation carried out during the last two years in the Geological Department of the University of Manchester. It refers mainly to the Permo-Triassic belt, which separates the coalfields of Ashton and Pendleton, containing the Manchester coalfield as an island in the centre. A detailed and careful consideration of all available records of borings has led to the following among other conclusions. There is no evidence of unconformity between the Permian and Bunter. The Bradford fault is certainly, and the Irwell fault probably, to a large extent pre-Permian. There is some evidence that the Upper Coal-measures extend close to the surface from Collyhurst, under Cheetham, to Agecroft, and a considerable area of productive measures is probably within easy reach north of this line. An important N.W.–S.E. fault bounds the area just mentioned on the N.E., and the productive measures are probably too deep for some distance north of this line. The total thickness of the Permian strata is about 1,000 feet, while the Bunter Sandstones measure at least 760 feet. Part of the "Permian" Sandstones probably belong to the Upper Coal-measures. R. H. R.

II.—The Association of Facetted Pebbles with Glacial Deposits. By J. W. Jackson. Mem. and Proc. Manchester Lit. and Phil. Soc., vol. lxii, No. 9.

FACETTED and wind-worn pebbles are described from Lancashire and Cheshire, and it is shown that they are of post-Glacial and pre-Neolithic age. The author considers, in accordance with the conclusion previously reached by Dr. Bather, that such pebbles do not in themselves provide evidence of arid or steppe conditions. At the close of glaciation in any country the land must have been bare, strewn with pebbles associated with an abundance of sand, and exposed to winds. Remembering that many of the pebbles had been already fractured by frost, the conditions were thus favourable for the development of facetted pebbles by the action of a natural sand-blast. It is suggested that an intimate connexion exists between the period of wind-erosion and the deposition of the æolian sand of Shirdley Hill.

III.—Yorkshire Type Ammonites. Edited by S. S. Buckman. Photographs mainly by J. W. Tutcher. Part xvii, pp. xiii, xiv, 8 plates and descriptions Nos. 117–119. London: Wesley. 1918.

THIS part is remarkable for the number of new names, not always of classic elegance. *Fimbrilytoceras* is for "the series to which *Am. fimbriatus*, Sowerby, belongs", since *A. fimbriatus* d'Orb., is the genotype of *Lytoceras*. The two genera are contrasted. "Owing to the regulations of the Oxford University Museum, photographs of" the holotype of *A. fimbriatus* Sow. "could not be obtained"—a statement that needs explanation. *Pseudocadoceras* is based on one syntype of *A. longævus* Bean, while the other syntype, now the lectotype, becomes the genotype of *Longæviceras*. *Eboraciceras* (an uneasy name) is founded for *A. dissimilis* Brown, here refigured; *Prorsiceras* for *A. gregarius* Bean-Leckenby, also refigured; and *Vertumniceras* for *A. vertumnus* Leckenby, as mentioned in the preceding Part. These last four are Cadoceratidæ. *A. crassus* Young & Bird, is refigured and referred to *Cœloceras*. Plates are also given of *Bifericeras parvum* (S. Buckman, 1904, sub *Microceras*), *B. nudicosta* (Quenst.), and *Beaniceras rotundum* nov. (based on *Ammonites centaurus* J. Buckman); but these are not from Yorkshire. The descriptions convey a large amount of information to those who will trouble to interpret them; the clear photographs speak for themselves.

IV.—The Water Supply of Essex. By W. Whitaker and J. C. Thresh. Mem. Geol. Survey. pp. 510 and 4 maps. 1916. Price 15*s*.

THE memoir contains, in addition to well-records, chapters dealing with the water-bearing beds, rainfall, chemistry of Essex waters with analyses, contamination and risk thereof, supplies from springs, wells, and borings.

It is accompanied by an extensive bibliography and by maps showing (1) the underground water-level in the Chalk around the head-waters of the Stort and Cam, (2) the amount of chlorine in deep-well waters, (3) wells giving alkaline waters, (4) the rainfall.

V.—Geological Structure of the Union of South Africa. By A. W. Rogers, Sc.D. pp. 13, with a coloured map. Reprinted from the Official Year Book, 1917.

IN the space of thirteen pages Dr. Rogers manages to give a very complete account of the physiography and geology of the Union territories, which cover an area of no less than 476,000 square miles. The account is necessarily much compressed, but still a brief description is given of the characters and distribution of the long succession of rock-formations represented. The latest results of South African stratigraphy are condensed into a tabular form, giving the correlation and thicknesses, so far as known, of all the scattered and puzzling rock-groups which, in the absence of fossils, have given so much trouble to South African geologists. It is interesting to note that the Malmesbury series of the Cape Province is now definitely regarded as equivalent in a general way to the Transvaal or Potchefstroom system, and that the Matsap series of Griqualand West is now placed on the same horizon as the Waterberg, and below the Table Mountain Sandstone. The ages of the different series of igneous intrusions are also indicated, and their close connexion with periods of earth-movement come out clearly in the table. The intrusion of the Bushveld complex is considered to belong to the age of the Waterberg system. The enormous total thickness of the South African sedimentary rocks is very striking, especially when considered in connexion with the peculiar conditions under which many of them were deposited, as, for example, the Karroo system. Altogether South African geology presents many problems of interest towards the solution of which Dr. Rogers and his colleagues of the Geological Survey have made very notable contributions.

R. H. R.

VI.—The Cassiterite Deposits of Tavoy. By J. Coggin Brown. Rec. Geol. Surv. India, vol. xlix, pt. i, pp. 23–33, 1918.

AT the present time Tavoy is one of the most important wolfram-mining centres of the world, but the occurrence of tin in notable quantities has been somewhat overlooked. Cassiterite occurs as an accessory mineral with wolfram and molybdenite in the granite, and in pegmatite veins and quartz lodes with ores of tungsten, bismuth, iron, copper, arsenic, antimony, lead, and zinc.

In the lodes cassiterite is almost always in close association with wolfram; in the Paungdaw-Wagon area the mixed concentrates may contain as much as 25 per cent of tin ore; cassiterite tends to be more common than wolfram in the greisens. The methods of lode-working still in use are somewhat primitive, being chiefly "cobbing and panning": the installation of a magnetic separator at Tavoy has improved the quality of the concentrates shipped.

The greater part of the output, however, comes from detrital deposits, which are exploited by hydraulic methods, especially by monitors. The richest tin-placers appear to be of sub-recent or late Tertiary age, forming raised river terraces and lake deposits and

raised marine clay banks along the Tavoy estuary. The tin-bearing beds of the Kanbauk area must have been laid down in a rapidly sinking valley, but recent movements of the land were in an upward direction. The author gives a list of localities in which he suggests that prospecting is likely to give good results.

R. H. R.

VII.—Timiskaming County, Quebec. By M. E. Wilson. Memoir 103, Canada Department of Mines, No. 86, Geological Series. pp. 197, with 16 plates, 6 text-figures, and a map. Ottawa, 1918.

THIS well-produced memoir is a general statement of the results of geological work carried on for several years in the north-western part of the province of Quebec. Besides the special and detailed descriptions of the local geology of Timiskaming County, it contains a good general account of the geology of the Ottawa basin, which comprises rocks of early and late Pre-Cambrian and Lower Palæozoic age. The former are included by the author in the Basal Complex, Huronian, and Keweenawan groups, while the Palæozoic sediments contain representatives of the Ordovician and Silurian systems.

Timiskaming County lies wholly within the Laurentian plateau and possesses in part the rocky-lake topography characteristic of that region, but part of it is occupied by plains of Post-Glacial lacustrine clay, forming what is generally known as the "clay belt". There are also numerous linear gorge-like valleys, which are believed to be of tectonic origin.

The lowest rocks seen in the area are the gneisses and limestones of the Grenville series. These are succeeded by the sediments and igneous rocks, extrusive and intrusive, of the Abitibi series, into which are intruded the Pre-Huronian batholiths. Upon these lie unconformably the Cobalt series, consisting of conglomerate, arkose, greywacke, and argillite. The Keweenawan rocks are mainly of a basic character, ranging from olivine-gabbro to syenite-porphyry.

The Ordovician Black River Limestone is probably separated by an unconformity from the calcareous sandstones and limestones of the Niagara series, the youngest formation represented in the district, with the exception of the Glacial and Post-Glacial deposits. Hence it is seen that the geological sequence in this area is remarkably incomplete.

The Cobalt series shows some features of considerable interest, since many of its members are believed to be of glacial origin: they show a remarkable similarity, allowing for natural processes of alteration, to the deposits of the Pleistocene continental ice-sheets, laid down under lacustrine conditions in the outer zone of an area of glaciation.

The deposits composing the clay belt consist chiefly of finely laminated beds of clay and silt with occasional thin layers of calcium carbonate, sometimes passing into sandy beds. These were probably laid down in a great glacial lake, which is provisionally called Lake

Barlow. It does not seem to have formed part of Lake Algonquin, as suggested by Coleman.

The economic products of the county are not very important so far as is known: they include gold, silver, and molybdenite, but the only mine actually working produces galena. It is possible, however, that the veins of molybdenite may prove to be of value owing to the present high price of this ore.

VIII.—Rainy River District, Ontario, Surficial Geology and Soils. By W. A. Johnston. Canada Department of Mines, Geological Survey Memoir 82. pp. 123, with 8 plates, 1 text-figure, and a coloured map. Ottawa, 1915.

THE Rainy River District lies about half-way between the head of Lake Superior and the Red River of Manitoba, near the International Boundary, and has a total area of 1,051 square miles, mostly covered by superficial deposits of Quaternary and Recent date, underlain by pre-Cambrian rocks. The superficial deposits consist for the most part of boulder-clays and other glacial material, together with lacustrine sediments laid down in lakes formed during the retreat of the ice-sheets, and a considerable area of recent alluvium, wind-blown sand, and peat.

A variety of drifts are found in the district formed by the Keewatin and Labradorean glaciers, as well as lacustrine deposits of a marginal lake described as "pro-glacial Early Lake Agassiz", a predecessor of Lake Agassiz proper: the genesis of this lake is discussed in some detail.

The main object of this memoir is the study of the soils and their economic possibilities. Much of the country is forest-clad, and the soils have for the most part the light colour characteristic of well-timbered regions, apparently belonging to the "grey forest soils" of the Russian classification: there are, however, large areas of peaty, and what American writers pleasingly call, "muck" soils. Detailed descriptions are given, with mechanical analyses of the soils lying on the different types of surface accumulations: most of them are somewhat heavy in character, the only light soils of importance being the sandy and gravelly loams of the old beach ridges, and the lacustrine sands. The heavier soils, which are for the most part still virgin, appear to be very fertile when properly drained.

IX.—Canada Department of Mines, Summary Report, 1917. Part D. pp. 46. Ottawa, 1918.

THIS short report contains descriptions of certain areas in Manitoba which have recently been examined, largely with a view to their economic possibilities in the direction of mining and agriculture. The districts described include the Schist Lake, the Wekusko Lake, and the Star Lake areas, the gold-bearing region of S.E. Manitoba, the Falcon Lake molybdenite region, and the refractory occurrences of the Swan River Valley. A reconnaissance soil-survey was also carried out along the line of the Hudson Bay Railway.

X.—South Australia, Department of Mines, Mining Review for the Half-year ended June 30, 1918. No. 28. Adelaide, 1918.

AFTER the usual summary of outputs and values of minerals, this issue goes on to describe several interesting mineral occurrences.

Bores put down by the Government diamond drill on the Yelta Mine, adjoining the Moonta Mines property, traversed a copper-bearing lode which in one bore swelled to a rich ore body 21 feet thick, with an average copper content of 27 per cent, rising in places to 34·5 per cent; the lode is enclosed by the same country rock as that of the Moonta Mines.

An account is given of a graphite field on Eyre's Peninsula. The soil over part of the field is covered with a crust of travertine, but where this is absent flake graphite and graphite-bearing stones are found in a structureless subsoil stained with limonite. Magnesite is present and quartzite fragments are frequent. The nature of the decomposition products shows that the graphite has been developed in a series of sediments which have been greatly altered and invaded by pegmatites, and are now represented by a mixture of lime-silicate rocks and gneisses, such as are formed by the alteration of impure dolomitic limestones. The workings have not yet been carried below the zone of weathering, but the indications of workable graphite are promising.

In the county of Fergusson, on Yorke Peninsula, alunite has been discovered in the sea cliffs in a bed of clay resting on polyzoal limestone. The rocks are Tertiary in age and are overlaid by 50 feet of clay and 20 feet of travertine or superficial limestone. The alunite occurs as irregular layers, from 1 inch to 9 inches in thickness, and as nodular masses arranged in layers along a total width of about 12 chains.

The mode of origin of the alunite is rather obscure, but there are two possible explanations: the first supposes that the mineral was derived from sulphates generated from pyrites and from potash in the clay, and this idea is supported by the fact that samples of the same clay from a point a few miles away contain from 1·7 to 5 per cent of potash and from 2·38 to 0·23 per cent of SO_3 respectively. Alunite is soluble in sulphuric acid and, on coming within the influence of the limestone, the excess acid would be destroyed with the precipitation of the alunite immediately above the limestone. On the other hand, alunite is also known to have been derived from solutions rising from depth, and this may be the case here. It is likely that the fault fissures in the limestone along which the solutions could ascend did not extend into the clay, and that the alunite was therefore deposited just above the limestone.

The mineral is worked along adits from the shore; the samples taken contained from 60 to 87 per cent of alunite, corresponding to 6·3 to 9·3 per cent of K_2O.

W. H. W.

XI.—Permian Insect Remains from Sydney, N.S.W.

A Fossil Insect-wing from the Roof of the Coal-seam in the Sydney Harbour Colliery. By R. J. Tillyard. Proc. Linn. Soc. N.S.Wales, xliii, pp. 260–4, 1918.

THIS specimen is the portion of the fore-wing of an Orthopterous insect referred to the family Elcanidæ, and described as *Elcanopsis sydneiensis*, n.g. et sp. The horizon is Upper Permian. Members of the family are already known from the Lias and Upper Jurassic, and show an increasing tendency in their venational plan to the Acridiidæ of the present day. This new genus shows a still greater reduction in the number of branches of the radial sector and the number of cross veins, and suggests that the Acridioid plan may have been formed by the addition of new elements to what was originally a simpler and more open type of venation.

XII.—Diastrophic and other Considerations in Classification and Correlation and the Existence of Minor Diastrophic Districts in the Notocene. By J. Allan Thomson. Trans. New Zealand Inst., vol. xlix, pp. 397–413, 1916.

THE principles of diastrophism have been employed by Marshall, Speight, and Cotton in the correlation of the younger rocks of New Zealand. The succession of these rocks affords an example of a cycle of sedimentation between two periods of earth-movement, the middle of the cycle being marked by the occurrence of deep-water limestones. These authors assumed that the limestones were everywhere of the same age, although the palæontological evidence was incomplete. All the rocks formed between the early Cretaceous (post-Hokonui) and Kaikoura (late Tertiary) disturbances were named by Marshall the Oamaru system. Dr. Allan Thomson brings forward evidence to show that sedimentation began at very different times in different parts of the country, and that the Ototara, Otaio, Amuri, and Whangarei limestones are not contemporaneous. These limestones each represent a local maximum of depression due to provincial warpings of different diastrophic districts. For all strata deposited between the post-Hokonui and Kaikoura deformations the name Notocene is proposed, in order to avoid the necessity for exact correlation with the European Cretaceous and Tertiary divisions. In the same way it is suggested that the most recent superficial deposits, younger than the Kaikoura deformation, should be classed as Notopleistocene, since in the absence of mammals it is impossible to establish their equivalence with the subdivisions of the European and American Pleistocene. Some of these recent formations have undergone a good deal of tilting; in one place river gravels were observed dipping at 12° to the south-east: this suggests that the Kaikoura deformation lasted longer in some districts than in others and may even yet be in operation locally.

A description is given in an appendix of a new fossil, *Pachymagas abnormis*, n.sp., from sand interbedded with the Mount Brown limestone, Weka Pass, Canterbury.

R. H. R.

REPORTS AND PROCEEDINGS.

I.—The Royal Society. *December* 12, 1918.

"The Four Visible Ingredients in Banded Bituminous Coal." By M. C. Stopes, D.Sc. Communicated by Sir George Beilby, F.R.S.

The coal discussed is the ordinary streaky bituminous coal of the British Coal-measures widely used in home and factory.

Disregarding for the time being the ultimate morphological nature of the plant organs contributing to them, four differing substances or constituents are described as composing such coal. These can be recognized by differences in their general character.

1. Differences in their macroscopic appearance and texture (i.e. with the naked eye in hand specimens).

2. By their different behaviour when treated with various chemicals.

3. By the differences in the débris of each which result from their treatment with various chemicals.

4. By the differences in microscopic sections of untreated samples of each.

These differences are further followed up by analyses and distillations to be considered in a later paper.

Diagrams are given to show the characteristic distribution of these constituents in section, and to indicate, if not a parallel to, at least a possibly useful comparison with, petrological work on rocks.

The four ingredients thus determined are fusain (the already widely discussed "mineral charcoal"), and durain, clarain, and vitrain, the three latter names being given now for the first time.

II.—Geological Society of London.

1. *December* 4, 1918.—Mr. G. W. Lamplugh, F.R.S., President, in the Chair.

The following communication was read:—

"The Carboniferous Succession of the Clitheroe Province." By Lieut.-Colonel Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and Albert Wilmore, D.Sc., F.G.S.

The tectonic structure of the province consists of three dissected parallel anticlinal folds in beds of Carboniferous Limestone, Pendleside, and Millstone Grit age. The general direction of the axes of these folds is east-north-east and west-north west. Dissection has exposed the lower beds of Z, C, and S age, as the tectonic axes and beds of D, P, and Millstone Grit age occur on the flanks.

The Limestone sequence shows all the zones from Z to D. *Modiola* and *Cleistopora* phases have not been exposed, the base of the Carboniferous not being seen. The Z beds are much thickened, and not so fossiliferous as in the Bristol Province. C and S beds are, as a rule, well-bedded, with shales intercalated between beds of limestone. There are crinoidal beds of considerable thickness in places, and shell-breccias are common in S. *Zaphrentis omaliusi* indicates an important horizon in Lower C, and these beds are characterized by numerous large Gasteropods. *Productus humerosus*

(*sublævis*) marks an equally important horizon in Upper C, as it does in the Belgian Province.

D beds are peculiar in the western part of the Clitheroe Province, and are largely represented by shales, mudstone, and thin earthy limestone; but in the north and north-east in the Settle and Burnsall districts, thick, fossiliferous, obscurely bedded limestone with a rich brachiopod and molluscan fauna occur.

The Pendleside Series is well developed, and practically the whole sequence is exposed on the north-western flank of Pendle Hill. This series can be subdivided into life-zones by the Goniatites.

The lower 300 feet consists of well-bedded earthy limestones with much chert, characterized by the presence of *Prolecanites compressus*. As a rule, there is a well-marked limestone horizon, which the authors name the Ravensholme Limestone (from a farm of that name at the north-eastern end of Pendle); this limestone contains *Zaphrentis amplexoides*, *Cyathaxonia rushiana*, *Michelinia tenuisepta*, and *M. parasitica*, and the fauna is a very important and constant feature throughout the whole province. The Ravensholme Limestone is an important part of the "Pendleside Limestone" of the late Mr. R. H. Tiddeman.

The Pendleside Limestone is succeeded by hard, black, calcareous shales with *Glyphioceras striatum*, *Nomismoceras rotiforme*, and *Posidonomya becheri*; and these in turn by the Bowland Shales of Phillips, which contain the zones of *Glyphioceras spirale* and *Glyphioceras bilingue*.

The Upper Pendle Grit succeeds the zone of *Glyphioceras bilingue*, and is the homotaxial equivalent of Farey's Grit of the Peak Country.

An important horizon occurs between the Kinderscout and the Millstone Grit—Sabden Shales—characterized by a rich fauna with *Glyphioceras beyrichianum* and *Glyphioceras reticulatum*. It is considered probable that the well-known fossiliferous Hebden Bridge Beds may be on this horizon rather than in the Pendleside Series.

TABLE OF GONIATITE ZONES.

	"Middle" Coal-measures.	*Gastrioceras carbonarium*, von Buch.
	Lower Coal-measures.	*G. carbonarium*, von Buch.
	Upper Millstone Grit.	*G. listeri*, Martin.
	Sabden Shales.	*Glyphioceras diadema*, Beyrich.
Zones of the Pendleside Series.	Shales below Millstone Grit.	*G. bilingue*, Salter.
	Bowland Shales.	*G. reticulatum*, Phillips.
		G. spirale, Phillips.
		G. striatum, Phillips.
	Posidonomya becheri Shales.	*Nomismoceras rotiforme*, Phillips.
		Prolecanites compressus, Sowerby.
	Carboniferous Limestone D_2.	*Glyphioceras crenistria*, Phillips.

2. *December* 18, 1918.—Mr. G. W. Lamplugh, F.R.S., President, in the Chair.

The following communication was read:—

"On a Bed of Interglacial Lœss and some Pre-Glacial Freshwater Clays on the Durham Coast." By Charles Taylor Trechmann, D.Sc., F.G.S.

A few years ago the author described a bed of Scandinavian drift that was found filling up a small pre-Glacial valley-like depression at Warren House Gill on the Durham coast. This section and others north and south of it have been kept under observation at different times, and several new features have been noticed as the high tides and other agencies exposed parts of the coast.

Towards the southern end of the old pre-Glacial valley at Warren House Gill a bed of material, varying from 4 to 12 feet in thickness, was found overlying the Magnesian Limestone and also the Scandinavian drift. This material has been carefully examined chemically and microscopically, and proves to be identical in chemical and physical characters with a sample of the true Continental lœss. It is light-brown or fawn in colour, very porous, and extremely finely divided, and is devoid of plasticity. Towards the base, where it has not been disturbed since it was laid down, it contains a number of rounded and elongated, often very hard, calcareous concretions. In the cliff section it shows little or no trace of bedding, but tends to break down along vertical clefts and cracks. It passes upwards into a few feet of material that consists of lœss which has been partly redeposited by water, and is mixed with sand, gravel, and other material derived from Scandinavian drift.

The bed of lœss and redeposited lœss-like drift has suffered much decalcification and weathering; near its surface there was a large boulder of Norwegian titaniferous syenite which was superficially rotted and decomposed to a considerable depth. Smaller granitic erratics in the redeposited lœss are generally very much rotted. The limestone rubble and stones beneath the lœss are strongly calcreted, apparently by material leached out of the lœss. In a fissure beneath the lœss some mammalian bones were collected, including astragali of two species of *Cervus*. It is argued that the formation and subsequent decalcification of the lœss-deposit lying upon the Scandinavian drift indicates an interglacial lapse of considerable duration, as great as that which Continental geologists call an Interglacial Period, before the overlying English and Scottish drift was deposited.

About 2 miles south of the Scandinavian-drift-bed several fissures occur in the Magnesian Limestone cliffs and on the foreshore, filled with various materials that were transported in front of the earliest ice-sheet that advanced upon this part of the coast. The author has already recorded the occurrence in these fissures of Upper Permian red and grey marls and dolomites with clay and peaty trees. Continued examination of two of the fissures where they are exposed between tide-marks on the shore resulted in the finding of a quantity of freshwater mollusca, Ostracoda, and fish-remains. Some mammalian remains also occurred, including those of an elephant (probably *Elephas meridionalis*) and of a vole (*Mimomys*).

Vegetable matter has been washed from various parts of the clay. A large number of seeds came from a single patch of clay, and prove to be of Teglian age; they seem to represent a pre-Glacial flora, half of the species of which are either exotic or extinct. Seeds from

other parts of the deposit appear to indicate a later horizon and contain mainly living forms.

The deposit is a mixed one, and seems to have belonged to a series of late Pliocene and early Pleistocene beds that occupied part of the present area of the North Sea and were torn up by the advancing ice-sheet, like a great glacial erratic, and thrust into the fissures.

The fact that the Scandinavian drift in Durham contains only stones of Scandinavian origin has been confirmed, and the marine Arctic shells that occur in it were further collected, and a few additions to the faunal list were made. The most interesting of these is *Cyrtodaria siliqua*, Spengler, an American shell which has been recorded hitherto in Great Britain only from the Caithness Boulder-clays.

All the deposits described above are overlain and overridden by the main mass of local Cheviot and Northern drift that caps the cliffs of the Durham coast.

A suggested correlation of the Durham sequence with the European drifts is attempted, and it is concluded that the fringe of the Scandinavian ice-cap that reached the Durham coast probably corresponds with that of the second and greatest glaciation of Scandinavia, which some Continental geologists correlate with the Riss Stage of the Alps.

In that case the main local drift of the north-eastern coast falls into the third and last Glacial Period of Northern Europe. The evidence for Interglacial lapses in the local drifts is very inconclusive.

All the observed features seem to point to the fact that the Scandinavian ice-sheet advanced on the east coast of England in the same way as it invaded Northern Europe round the southern shores of the Baltic, and gave rise to analogous climatic conditions leading to the formation of loess, a fragment of which is found protected from the erosive action of the later local glaciation in a small hollow on the Durham coast.

III.—Edinburgh Geological Society.

November 20, 1918 (received December 13, 1918).—Professor Jehu, President, in the Chair.

"The Iron-ore Deposits of Noblehouse and Garron Point and their Genesis." By Dr. J. S. Flett, F.R.S.

In the Upper Cambrian rocks, which form a narrow band along the southern border of the Highlands, thin beds of iron ore occur among cherts and pillow-lavas. They are best exposed at Garron Point and Craigeven Bay, about a mile north of Stonehaven. Owing to their limited extent and irregular character, no attempt has been made to work them. At Noblehouse, in Peeblesshire, the Arenig pillow-lavas and cherts contain at least one bed of iron ore which was mined, though not with much success, at two periods during the nineteenth century. In both these cases the iron ore occurs as beds interstratified with cherts and shales, which were deposited on the sea bottom shortly after eruptions of pillow-lava had taken place.

Although in Great Britain pillow-lavas and cherts are widely distributed, there are few records of iron-ore deposits in connection with them. In other parts of the world, however, some of the most important beds of iron ore belong to this association In Germany the Lahn and Dill districts and the Upper Harz contain beds of iron ore in Middle and Upper Devonian strata; these rest on pillow-lavas and tuffs (schaalsteins), and are not uncommonly interbedded with cherts. For several years it has been clearly realized by German geologists that these deposits are products of the pillow-lava eruptions; and it is considered that they may have originated from emanations of ferric chlorides and other salts arising from the lava-flows during cooling.

The greatest iron-ore field of the present day is the Lake Superior district of the United States. Iron formations consisting of cherts and beds of hæmatite (sometimes siderite, magnetite, or limonite) are there found in pre-Cambrian rocks, principally the Keewatin and the Huronian. According to Van Hise and Leith, they are in all cases attended by eruptions of pillow-lava, and the source of the iron is to be traced to discharges of soluble iron salts proceeding from these lavas during their outflow, or shortly after they had come to rest.

In Northern Sweden and Lapland great masses of iron ore have long been known, and are mined on a very extensive scale. They are principally magnetite, with varying amounts of apatite, and are usually associated with syenitic eruptives, frequently rich in albite. Recently it has been shown that in the Kiruna district these eruptives belong to a suite in which pillow-lavas are strongly represented, and that all the rocks are very commonly albitized. The "syenites" (also described as "keratophyres") are the acid or leucocratic members of a "spilitic" suite. The iron-ore deposits are variously interpreted as stratified beds, magmatic segregations, and contact deposits.

Submarine deposits of iron ore in beds, such as the Noblehouse and Garron Point deposits, resting on or associated with pillow-lavas, are accordingly of worldwide distribution and sometimes of the highest economic importance. Their formation is due to the abundant discharges of vapours and salts from the cooling lava-flows, and, like the albitization and siliceous formations that characterize this group of rocks, they mark the special propensity to pneumatolytic discharges which is one of their distinctive peculiarities.

CORRESPONDENCE.

THE YUNNAN CYSTIDEA.

SIR,—Dr. Bather's articles (GEOL. MAG. November and December, 1918) on the Yunnan Cystidea described by me in the *Palæontologia Indica*, N.S., vol. vi, Mem. No. 3, 1917, appear to require some notice, if only to correct some unfortunate mistakes into which he has fallen. But in the first place he may be congratulated on having at last published a clear terminology and definition of the morphological planes of the Cystidea which will avoid subsequent misinterpretation of his descriptions.

With regard to the genera *Sinocystis* and *Ovocystis* which Dr. Bather would unite, it is regrettable that when he had the actual figured specimens to examine his customary accuracy of observation seems to have been wanting, so that he has been led to doubt the presence of certain characters which I described. Indeed, he candidly admits (Geol. Mag. for November, p. 513) that he did not notice one of the structures in question till he had read my memoir and sent back the specimens. It must be accordingly concluded that his remarks are partly based on the casts and figures with their unavoidable defects and limitations. Two points may be specially mentioned. (1) *Sinocystis loczyi*. Of the many specimens of this species which were submitted to me for study, of which only a few were figured, it was observed that only in a very few instances was the summit of the tubercles missing and the diplopores exposed, and that this was due to abrasion, as clearly shown by the condition of the rest of the theca. In both large and small specimens the uninjured surface of both species of this genus possessed a thick layer of epistereom covering the tubercles and concealing the openings of the diplopores. In *Ovocystis mansuyi*, on the other hand, the diplopores were always seen to open freely on the surface, whether the specimens were large or small, worn or undamaged. The good preservation of much of the material which passed through my hands seems to render these facts beyond doubt. (2) The runnels on the surface of *Ovocystis mansuyi*, to which I applied the term "food-grooves" with perhaps too easy an assumption of their function, are more or less distinctly seen in a large number of the specimens which I examined, and are frequently quite conspicuous features impossible to confuse with the normal depressions between the plates of *Sinocystis* or *Ovocystis* itself, though Dr. Bather believes that they are of this nature and devoid of significance. It is true that they have not come out well in the collotype reproductions and much less in the casts on which he relies, but there can be no question as to the existence of these strange and often irregular grooves on the surface, whatever view we hold as to their character. If Dr. Bather had had the advantage of studying the large series of specimens which I had, and of observing the different degrees of development of these runnels, he would not have questioned their existence. Whether the differences between *Sinocystis* and *Ovocystis* are sufficient to separate them generically after taking into account these and other points which I mentioned may be a matter of opinion, but the presence and constancy of such characters have to be admitted.

F. R. C. Reed.

Cambridge.
December 18, 1918.

THE GENESIS OF TUNGSTEN ORES.

Sir,—In reply to Mr. J. Coggin Brown's letter in the January number of the Geological Magazine on the Genesis of Tungsten Ores I should like to state that my paper on that subject was written in the first two months of 1918. The valuable lecture by Dr. Jones was reprinted in the *Mining Journal* in March, 1918, but

I was unable to see the collected edition of the Tavoy lectures, published at Rangoon, until October, when Mr. J. F. L. Vogel, of High Speed Steel Alloys, Ltd., of Widnes, was kind enough to lend me the copy belonging to his company. I need hardly say that I should have been only too pleased to quote the results of more recent work had such been available at the time. Much of the difficulty of obtaining information no doubt arose from the prevalence of war conditions and the slowness of communications, but it is much to be regretted that geologists who have worked in Tavoy have almost always elected to publish their results in more or less obscure and inaccessible forms; copies of such publications are not always to be found in the principal scientific libraries. May I venture to suggest that the pages of the Geological Magazine are readily open to receive either original contributions or abstracts of other publications on matters of such high scientific interest and practical importance?

R. H. Rastall.

OBITUARY.

GROVE KARL GILBERT.

Born 1843. Died 1918.

Grove Karl Gilbert was born at Rochester, N.Y., on May 6, 1843. He received his early education in the same city and graduated in the classical course at the University there. After a year spent in teaching at Jackson, Michigan, he returned to Rochester, where he was employed for five years as assistant to a well-known dealer in scientific materials. In 1868 he became a voluntary assistant on the Ohio Geological Survey, but his real career may be said to have commenced in 1871, when he joined the Survey of Utah, Nevada, and Arizona; here Gilbert began the field-studies which led to the great work of his life, the investigation of the dependence of physiographic form on geological structure. The earlier publications of this Survey contained his exposition of the fault-block structure of the Basin Ranges and his masterly monograph on Lake Bonneville. In 1876 he explored the Henry Mountains and put forth the now accepted explanation of the peculiar forms of igneous intrusions, introducing the well-known term "laccolith". The report on the Henry Mountains also contains a chapter on land-sculpture, which is a classic of geological literature and the foundation of modern theories of denudation and the development of river-systems.

From 1884 to 1888 Gilbert was employed in the Appalachian region and occupied high administrative posts on the United States Geological Survey. Later he studied many other parts of the United States, including the Great Lakes and Alaska. He published a volume on the history of the Niagara River and a report on Earth-movements in the Great Lakes Region. His observations in Alaska in 1899 led to his introduction of the now universally used term "hanging valleys" with an explanation of their origin.

The physiographic work of G. K. Gilbert must always remain one of the outstanding features of physical geology in the nineteenth

century; while it cannot be denied that he enjoyed exceptional advantages in working in regions built on a large scale and of notable simplicity of structure, nevertheless it needed a broad grasp of principles and great powers of generalization to formulate the laws of geological processes and their results which will ever be associated with his name. Not only in America, but throughout the world, his influence has made itself felt, and his death removes one of the outstanding figures of the geology of our time.

J. P. JOHNSON.

Born 1880. Died October 18, 1918.

J. P. Johnson was born in London, 1880, and died in Johannesburg, October 18, 1918. He was educated at Dulwich College and the Royal School of Mines. He made many important discoveries in the Pleistocene geology of the South of England, the results being published in the *Essex Naturalist*, the Proceedings of the Geologists' Association, and in the columns of this Magazine.

Considerations of health compelled him in 1902 to leave England for South Africa, and in this virgin field his early training stood him in good stead, and numerous works and papers testify to the good work he accomplished; the most important being: *The Mineral Industry of Rhodesia*, *The Ore Deposits of South Africa*, *Geological and Archæological Notes on Orangia*, *The Stone Implements of South Africa*, and *The Prehistoric Period in South Africa*; two editions have been published of the last two. He was a member of the Council of the Geological Society of South Africa, and was appointed by the South African Government a member of the Commision to report on the petroglyphs and rock-paintings of South Africa.

MISCELLANEOUS.

Post-War Honours.

His Majesty the King has been pleased to confer upon Dr. Aubrey Strahan, F.R.S., Director of H.M. Geological Survey, the title of "Knight Commander of the Most Excellent Order of the British Empire, established in 1917, for services rendered to the kingdom whether at home or abroad". Every geologist will congratulate Sir Aubrey Strahan on this well-merited recognition of his own personal labours and that of his admirable staff of co-workers, who have contributed so largely to our increased scientific knowledge of geology, both stratigraphically and economically, not only within the British Isles, but beyond; many members of the Survey having joined our Forces abroad.

Diamonds, South Africa.

A telegram from South Africa announces the discovery of a large diamond at the Jagersfontein Mine, in the southern portion of the Orange Free State. The new diamond weighs 388¼ carats, and is therefore small in comparison with such great gems as the Cullinan

and Koh-i-noor, but it is chiefly remarkable for its colour, which is described as soft blue and white. This is the second large diamond found in the last two years in the Union, for it will be remembered that a stone weighing 442½ carats was found in the Dutoitspan Mine, near Kimberley, in October, 1917.

Dr. F. H. Hatch described and figured "The Great Cullinan Diamond" in the GEOLOGICAL MAGAZINE for 1905, Vol. XLII, pp. 170–2, with two plates (VII and VIII) and a diagram of the external form in the text.

AWARD OF MEDALS BY THE GEOLOGICAL SOCIETY.

The Council of the Geological Society has this year awarded the Medals and Funds as follows:—The Wollaston Medal to Sir Aubrey Strahan, Director of H.M. Geological Survey; the Murchison Medal to Miss G. L. Elles, of Newnham College, Cambridge; the Lyell Medal to Dr. W. F. Hume, Director of the Egyptian Geological Survey; the Bigsby Medal to Sir Douglas Mawson; the Wollaston Fund to Dr. A. L. Du Toit, of the Geological Survey of South Africa; and the Murchison Fund to Mrs. Reid, widow of the late Mr. Clement Reid; while the Lyell Fund is divided between Mr. John Pringle, of the Geological Survey of England and Wales, and Dr. Stanley Smith, of University College, Aberystwyth.

PULCRUS OF ROME, THE FIRST TO MAKE A RESTORATION OF AN EXTINCT MAMMAL.

"The grammarian Apollonius relates that there was an earthquake during the reign of Tiberius Nero, through which many celebrated cities of Asia were entirely destroyed . . . In those parts in which the earth was rent asunder very large dead bodies were found; the magnitude of which, indeed, so astonished the inhabitants, that they were unwilling to move them. That the affair, however, might be generally known, they sent to Rome one of the teeth of these bodies; and this was more than a foot long. The ambassadors, at the time they showed this to Tiberius, asked him whether he wished that the hero to whom this tooth belonged should be brought to him. Upon this Tiberius very prudently thought of a means by which he might neither be deprived of knowing the dimensions of this body nor yet be guilty of the impiety of robbing the dead. He ordered a celebrated geometrician, whose name was Pulcrus, and whom he honoured for his art, to be called, and desired him to make a face in proportion to the size of that tooth. The geometrician, therefore, having calculated from the size of the tooth the dimensions of the face and of the whole body, accomplished the task imposed on him with great celerity, and brought the face to the Emperor, who, after he had satisfied himself with beholding it, ordered the tooth to be restored to the place from whence it was taken."—Phlegon Trallianus, "On Admirable Things," *ex notæ* Taylor, ed. Pausanias, i, 97, in iii (1824), 240.

C. DAVIES SHERBORN.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE VI. VOL. VI.

No. III.—MARCH, 1919.

EDITORIAL NOTES.

WITH the present number a new feature is introduced into the Geological Magazine, namely, an Editorial page. Hitherto announcements of events of current interest have been relegated to a section with the somewhat unsatisfactory title of "Miscellaneous" and have been confined within rather narrow limits. The intention is to extend this feature into the form of Editorial notes and comments on topical matters, personal, academic, administrative, scientific, and economic; in fact, any subjects bearing on the development and progress of geology at home and abroad. It is hoped by this means to extend the usefulness of the Magazine and to interest a still wider circle of readers by affording an opportunity for a free and informal discussion of the problems of the day. This is a period of altogether exceptional conditions and also, it is believed, the dawn of a new era in the history of science in general and of geology in particular. In order that geology may play its part in the great work of reconstruction that lies before us a wide dissemination of ideas is essential, and, without being unduly egotistical, it is the hope of the Editors that the Geological Magazine may take a humble share in this great task.

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Mr. Alfred Harker, M.A., LL.D., F.R.S., has been appointed Reader in Petrology in the University of Cambridge. There is at present no permanent Readership connected with Geology in the University, but "having regard to the long service and scientific achievements of Mr. Harker" it was decided that a special Readership should be established for him, the appointment to date from January 1, 1919.

* * * * *

At the annual meeting of the Geological Society, held on February 21, the officers for the ensuing year were elected as follows: President (for the second year), Mr. G. W. Lamplugh; Vice-Presidents,

Professor J. E. Marr, Sir Jethro Teall, Mr. R. D. Oldham, and Sir John Cadman; Secretaries, Dr. H. H. Thomas and Dr. H. Lapworth; Treasurer, Dr. J. V. Elsden; Foreign Secretary, Sir A. Geikie. The following were also elected to replace the five retiring members of Council: Dr. G. T. Prior, Professor P. F. Kendall, Dr. G. Hickling, Mr. A. Howe, and Mr. R. S. Herries.

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In view of the change in the political status of women brought about by the new Franchise Act it was inevitable that the question of their admission to the Geological Society should again be brought forward. In this connexion the award of the Murchison Medal to Miss G. L. Elles, as recorded last month, is significant. At the meeting of the Society on January 22 the President announced that a special general meeting will be held on March 26 to consider the following motion: "That it is desirable to admit women as Fellows of the Society." There can hardly be any doubt as to the outcome of the discussion, and we may hope that a long-delayed measure of justice will be carried out without serious opposition.

* * * * *

Messrs. George Allen & Unwin, Ltd., have done a useful service by publishing, under the title of *German Designs on French Lorraine*, a translation, with introduction, of the secret memorandum presented by the German iron and steel manufacturers to the Imperial Chancellor and to Field-Marshal von Hindenburg at the close of 1917. This is a document of remarkable interest in many ways, partly as an exposition of German unscrupulousness and cynical disregard for truth and partly as an example of how completely a case may be given away by excess of zeal. Since the main points brought forward are essentially matters of geological fact, distorted to suit German arguments, it may be briefly summarized here. The gist of the argument is as follows: Germany will require, after a peace victorious for the Central Powers, a greatly increased supply of iron and steel: her home supplies are approaching exhaustion, therefore it will be necessary for the continued existence of the Empire, and especially for the successful prosecution of the next war, to annex that part of Lorraine which still remains French. In order to diminish the atrocity of this annexation, the reserves still remaining in Germany are much under-estimated, while the amount of the supplies available in the rest of France are multiplied enormously. The figures given are stated to be on the authority of the well-known geologists Beyschlag and Krusch. These authorities value the average life of the German mines at 40 to 50 years. According to the best pre-War figures the German resources were in 1910 about 3,900,000,000 tons of ore: if this is to be exhausted

in 50 years it would correspond to an average yearly production of 35,000,000 tons of pig iron from home ores alone, without counting imports, an apparently impossible figure, and more than double the pre-War production. The figures given for France are still more startling. In 1916 a German engineer estimated the resources of Normandy at 500,000,000 tons of ore, but the authors of this memoir adopt the figure of 5,000,000,000 tons for this area, or ten times as much. As a subsidiary argument the urgent need for phosphatic manures, i.e. basic slag, for German agriculture is insisted on, and this can best be obtained from the Lorraine ores.

This memorandum in point of fact proves in the clearest possible manner that without the Lorraine iron-fields the German Empire can never again conduct a great European war, and the general impression left on the mind of the non-political reader is that the one thing that really matters at the present Peace Conference is the restoration of Lorraine to France; without this iron-field Germany, on her own showing, is helpless for good or evil for evermore. This is of course an exaggerated view of the case, nevertheless it is clear that the matter is of paramount importance, and it is much to be hoped that the geological aspect of it has been duly placed before the responsible authorities.

* * * * *

The issue of *Nature* for January 16, 1919, contains a valuable article by Mr. V. C. Illing on Borings for Oil in the United Kingdom. The whole subject is reviewed from an eminently practical and common-sense point of view; while due weight is given to the admitted occurrence of petroleum in small quantities in many British localities, especially in the Carboniferous, these are reduced to their true proportions, which are shown to be insignificant, and the author evidently entertains no hope of a commercially successful result from the investigations now proceeding. The article should be read in conjunction with the memoir on this and cognate subjects recently issued by the Geological Survey, which likewise pours floods of cold geological common-sense on the rosy optimism which has lately been prevalent in the columns of the daily press. Such a treatment of the subject was much needed, since the indulgence of such hopes can, in the opinion of competent geologists, only lead to disappointment. Although the scheme now in operation in Derbyshire is on a somewhat higher plane than the famous leaky tank at Ramsey, nevertheless it is to be gravely doubted whether the results will be of much more practical value. It is of course possible, however, that these extensive borings may yield other results of unlooked-for scientific or economic importance, apart from the problematical supply of liquid fuel.

ORIGINAL ARTICLES.

I.—Fossil Fishes in the Devonian Rocks of North Devon.

By Inkermann Rogers.

THE Devonian rocks in Devon, like those of the Old Red Sandstone of which they are the equivalents, have been divided into three groups. Mr. T. M. Hall,[1] writing in 1879, quoted no less than five separate classifications suggested for the beds of North Devon, nor has uncertainty been removed by the conclusions arrived at by geologists since that date.[2] But we may for present purposes take the following as the nearest approach to a generally accepted succession :—

Upper Devonian	Pilton Beds. Baggy Beds. Pickwell Down Sandstones. Morte Slates in part.
Middle Devonian	Morte Slates in part. Ilfracombe Beds.
Lower Devonian	Hangman Grits. Lynton grits and shales. Foreland grits and shales.

While examining the rocks of the Middle and Upper series for fossil plants during the past eleven years (1907–18), the results of which have already in part been published,[3] other discoveries were made incidental to the work of collection of plant remains. Among these the discovery of fossil fish remains seems worthy of special notice.

The object of this brief note is to describe the discovery of fossil fishes made by the writer in the Pickwell Down Sandstone within a few hundred yards of the junction beds of the Morte Slates. As far as he has been able to ascertain, it is with one exception the only find of such remains made in any of the North Devon rocks classified above as Upper Devonian. The exception is a scale of *Holoptychius*

[1] T. M. Hall, "Classification of the North Devon Rocks": Trans. Devon Assoc., vol. xi, pp. 180–90, 1879.

[2] J. B. Jukes, "On the Carboniferous Slate (or Devonian Rocks) and the Old Red Sandstone of South Ireland and North Devon": Q.J.G.S., vol. xxii, p. 320, 1866, and his pamphlet, *Additional Notes on the Grouping of the Rocks of North Devon and West Somerset* (privately printed), Dublin, 1867; R. Etheridge, "On the Physical Structure of West Somerset and North Devon": Q.J.G.S., vol. xxiii, p. 568, 1867; W. A. E. Ussher, "On the Palæozoic Rocks of North Devon and West Somerset": Geol. Mag., Dec. II, Vol. VIII, 1881, and "Cornwall, Devon, and Somerset": Jubilee Volume Geol. Assoc., 1910, p. 859; J. E. Marr, "On some Effects of Pressure on the Devonian Sedimentary Rocks of North Devon": Geol. Mag., Dec. III, Vol. V, 1888; H. Hicks, "On the Morte Slates and Associated Beds in North Devon and West Somerset": Q.J.G.S., vol. lii, p. 254, 1896, and vol. liii, p. 441, 1897; Rev. G. F. Whidborne, "Preliminary Synopsis of the Fauna of the Pickwell Down, Baggy, and Pilton Beds": Proc. Geol. Assoc., vol. xiv, pt. ix, p. 371, 1896.

[3] Arber & Goode, "On some Fossil Plants from the Devonian Rocks of North Devon": Proc. Camb. Phil. Soc., vol. xviii, pt. iii, p. 89, 1915.

referred to by Professor J. Phillips in his *Palæozoic Fossils*,[1] published in 1841, as having been discovered at Baggy Point.

On the shore at Woolacombe Sands, about a quarter of a mile south of Woolacombe, an isolated patch of Pickwell Down sandstones and shale, dipping to the south at an angle of 60°, projects seaward from the foot of the sand-dunes. This outcrop, which is locally known as Mill Rock, measures 60 feet by 50 feet, and rises from 6 to 7 feet above the level of the tidal sands. I have not seen it myself, but Mr. J. G. Hamling, F.G.S., who has visited the spot, informs me that the exposure is fragmentary and covered by "head". In the year 1913 Dr. Thomas Young, of Colyton, then of Woolacombe, called my attention to there being an igneous vein about 2 inches thick in Mill Rock. I obtained a sample of it and recognized it as volcanic tuff. Eastward the vein is met with in a rock cutting leading to a large quarry opposite Fox Hunter's Inn on the Braunton road, three miles from Woolacombe. Here it is 18 inches in thickness and badly weathered. Three miles still further eastward it is well exposed in an old quarry a little south of Bittadon. Here the bed is 25 feet thick, fully crystalline, and much weathered. Mr. Ussher,[2] and also T. M. Hall,[2] refer to it as the Bittadon felsite. It extends to Bratton Fleming, another six miles eastward. Here I have not seen it myself, but Mr. Hamling, F.G.S., who has, informs me that it is fragmentary and probably not more than two or three inches in thickness.

Recently (May, 1918) I polished a piece of the tuff from Mill Rock. On closely examining it I detected to my surprise what appeared to be fish-remains and a tooth, whereupon I determined to obtain further samples of the rock. The result was I found not only that there were fish remains in the tuff, but that fragments of bones and teeth could be observed in almost every part of Mill Rock. One lenticle of redeposited tuff mingled with shale was discovered containing several scales, portions of scales, and bone plates, as well as many small bones. These proved to be the remains of typical Upper Devonian fishes — *Holonema*, *Bothriolepis*, *Holoptychius*, *Polyplocodus*. All the specimens were forwarded to Dr. A. Smith Woodward, F.R.S., for examination, and he has kindly sent me the subjoined report.

[1] J. Phillips, *Figures and Descriptions of the Palæozoic Fossils of Cornwall and Devon and West Somerset*, p. 133, 1841. See also Rev. D. Williams, "On the Killas Group of Cornwall and Devon": Trans. Roy. Geol. Soc. Cornwall, vol. vi, pp. 122–38, 1843; R. Etheridge, "On the Physical Structure of West Somerset and North Devon": Q.J.G.S., 1867, p. 156; W. Pengelly, "The History of the Discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall": Trans. Devon Assoc., vol. ii, pt. ii, p. 423, 1868; J. G Hamling, "Recently Discovered Fossils from the Lower and Upper Devonian Beds of North Devon": ibid., vol. xl, pp. 276–80, 1908; "Excursion to North Devon, Easter, 1910": Proc. Geol. Assoc., vol. xxi, pt. ix, 1910.

[2] W. A. E. Ussher, "On the Palæozoic Rocks of West Somerset and North Devon": Proc. Som. Arch. and Nat. Hist. Soc., 1879, and "Cornwall, Devon, and Somerset": Jubilee Volume Geol. Assoc., 1910, p. 869; T. M. Hall, "Geology of the Ilfracombe Coast-line": Trans. Devon Assoc., vol. xi, p. 278, 1879.

Notes on the Fish-remains from the Pickwell Down Sandstones.

By A. Smith Woodward, LL.D., F.R.S.

The fish-remains discovered by Mr. Inkermann Rogers in the Pickwell Down Sandstones of Woolacombe Bay are merely scattered fragments. Some are sufficiently well preserved to exhibit their microscopic structure, but many are much obscured by the ferruginous infiltrations in the rock. A few appear to be generically determinable.

Holonema cf. ornatum, Traquair.—The most important specimens are two portions of dermal plates with an ornament much resembling that of the armour from the Upper Old Red Sandstone of Shetland named *Holonema ornatum* by Traquair.[1] The larger fragment is about as broad as long (measuring 9 cm. each way), but its borders are incomplete; and in both specimens the ornament is obscured by ferruginous stains which cannot be removed. The greater part of the plate is covered with low and rounded vermiculating ridges, which sometimes blend into a network; and the margin, to the width of about 2 cm., is ornamented with finer and closer straight ridges which are directed mainly at right angles to the edge. There are also some vague traces of tubercles on or between the ridges. The middle part of the larger specimen is 5 mm. in thickness; and a microscope-section of the smaller specimen shows that all the tissue is well preserved except that of the superficial ornament. The calcification is in almost structureless lamellæ, without bone-cells, and there are numerous irregular, horizontally-extended spaces between the lamellæ which give the plate a very open texture. The spaces are evidently all connected, for straight vertical canals are often conspicuous crossing the lamellæ. The structure of the plate is therefore similar to that of the Ostracoderms *Psammosteus* and *Drepanaspis*,[2] and very different from the true bone of Arthrodiran armour. This fact, indeed, suggests doubts as to whether the Shetland and Devon fossils are rightly ascribed to *Holonema*; for, although the microscopic structure of the original specimens of this genus from the Upper Devonian of North America remains unknown, the arrangement of the plates, so far as discovered, corresponds most closely with that of such an Arthrodiran as *Coccosteus*.

Bothriolepis.—The proximal end of the articular plate of an appendage and the remains of a posterior ventro-lateral plate belong to an Asterolepid, which other fragments of ornamented dermal armour seem to identify with *Bothriolepis*. The structure of the ventro-lateral plate, so far as preserved, agrees with that of the latter genus. The ornament of the other fragments is a coarse network of rounded ridges which often rise into low tubercles or are even subdivided into separate tubercles. In one specimen the most prominent ridges are concentric with the margin of the plate.

[1] Trans. Roy. Soc. Edinb., vol. xlvi, p. 327, pl. ii, 1908.

[2] J. Kiær, Rep. 2nd Norwegian Arctic Exped. *Fram*, 1898–1902, No. 33, pp. 28, 30, 35, text-figs. 5, 6, 8, 1915.

Some portions of the Asterolepid cancellous tissue belong to plates of considerable thickness. They may perhaps represent a *Bothriolepis* with a large dorsal crest, such as has been described by Traquair in a species from the Upper Old Red Sandstone of Elgin.[1]

Holoptychius.—One Holoptychian scale, shown in impression, is ornamented with very coarse rounded ridges, which are closely arranged and are not subdivided into tubercles. Another specimen, in which only a fragment of the original scale remains, shows by a clear impression that the inner face is destitute of a median tubercle.

Polyplocodus.—There are several isolated small Rhizodont teeth, which agree with those from the Upper Devonian of Russia and Scotland commonly named *Polyplocodus*.[2] They are not compressed to sharp edges, but rounded in section, and their outer face is marked by fine vertical grooves or striations. A microscope-section of two specimens shows the typical Rhizodont structure, and one broken tooth proves that the pulp-cavity extends upwards nearly to the apex. Part of the impression of one of these teeth is seen in a piece of Bittadon felsite.

Coccostean.—Some portions of tuberculated plates are probably Coccostean, but not sufficient for exact determination.

Conclusion.—The fish-fauna represented by the fossils from the Pickwell Down Sandstones is therefore typically Upper Devonian.

II.—The Facial Suture of Trilobites.

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Introduction.

TRILOBITES in common with all other Arthropods shed their more or less rigid external covering or exoskeleton periodically. To accomplish this ecdysis it is necessary for this covering to split somewhere; and it is highly probable that the facial suture was the line along which such splitting took place. There seems, however, to be a tendency to assume that all lines which served this purpose are homologous. This has introduced unnecessary difficulties into the study of Trilobite classification. The object of this paper is to do something towards the elimination of this source of error.

The Segmentation of the Head.

A consideration of the segmentation of the cephalon will do much to give precision to our ideas of the position and homologies of the facial suture.

Bernard[3] considered that the number of segments in the head region was not fixed, and that within the order Trilobita new

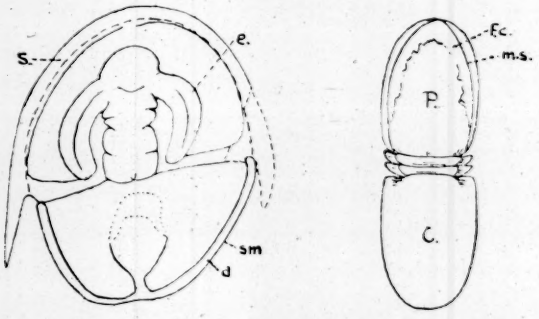
[1] *Bothriolepis cristata*, R. H. Traquair, *Fishes of the Old Red Sandstone* (Mon. Pal. Soc., 1906), p. 130, pl. xxxi.

[2] See R. H. Traquair in Brown & Buckley's *Vertebrate Fauna of Moray Basin*, 1896, p. 257.

[3] H. M. Bernard, "The Systematic Position of Trilobites": Q.J.G.S., vol. l, p. 414, 1894.

segments had been added to the posterior margin. He based this view upon two considerations: first, that the number of segments indicated on the axial portion of the dorsal side of the cephalon varied; second, that the last or occipital segment bears so close a resemblance to a trunk segment as to suggest that it had "been recently incorporated".

In discussing the former consideration, he observes that whilst the majority of trilobites show traces of five segments on the glabella, some, e.g. *Microdiscus* and *Triarthrus*, show only four. This line of reasoning is fallacious, for glabellar furrows are often reduced or smoothed out, so that if indications of four segments are left it is not safe to say that there are *not more* than four segments in the head, but it is safe to say that there are *at least* four. The presence of five segments on the glabella of *Eodiscus speciosus*[1] and the discovery since his day of five pairs of cephalic limbs in *Triarthrus* refute his first argument.



a *b*

Figures showing the position of the "facial suture" of Raymond and (?) Beecher in *Pœdeumias* and *Agnostus*. *a*. Head-shield of *Pœdeumias transitans* (Walcott) after Walcott (Smiths. Misc. Coll., vol. liii, pl. xxxiv, fig. 6). *b*. Carapace of *Agnostus nudus* (Beyrich) copied from Raymond (Amer. Journ. Sci., 1917, fig. 1). *d*. Doublure of *Pœdeumias* reflected from underneath the head-shield. *s.m*. Sutural margin of the doublure. *s*. Approximate position of the marginal suture (facial suture of Raymond) on ventral surface. *e*. Eye. *c*. Cephalon of *Agnostus* according to authors. *p*. Cephalon of *Agnostus* according to Raymond. *m.s*. Marginal suture ("ventral facial suture" of Raymond and ?Beecher) of *Agnostus*. *f.c*. Ventral free cheeks according to Raymond and (?) Beecher.

With regard to the resemblance of the occipital segment to the trunk segments, it may be observed that this is merely an illustration of the principle that in segmented animals specialization of the posterior lags behind that of the anterior segments. Thus, within the Trilobita the glabellar furrows are obscure or absent most frequently in front, and again, it is this part of the glabella that varies most in shape and dimensions; compare for example, such forms as *Conocoryphe*, *Olenus*, *Paradoxides*, *Phacops*, *Staurocephalus*.

[1] Bull. U.S. Geol. Surv., No. 30, p. 154, 1886.

Nevertheless, amid all these changes the occipital, and sometimes the next segment in front of it, retain a close resemblance to a trunk segment.

The fixity or non-fixity of the number of cephalic segments cannot be definitely settled until the ventral surfaces of many more trilobites are known. Meanwhile it is significant that in such widely separated genera as *Triarthrus* and *Marella*[1] five pairs of cephalic appendages occur and that the last pair in each case resembles those in front more than it does the trunk appendages. The existence of this condition in so primitive a form as *Marella* suggests that the cephalic segments became marked off as cephalic *en bloc*, and proves that the posterior limits of the head-shield became defined and the number of its segments fixed at a very early stage in the evolution of the order.

In all trilobites, young or old, which possess eye-lines or eye-lobes as well as a clearly segmented glabella, the line or lobe is related to the palpebral segment that is the fifth from the posterior margin. This is another fact which indicates that these five segments are homologous in all typical trilobites, and that no new segment has been added to the cephalon since definitive trilobites came into existence.

How many segments lie in front of the palpebral it is quite impossible to say. An additional one is sometimes indicated on the glabella.[2] This must be the ocular segment whose pleural portion bears the visual area of the eye upon its hinder margin. The segmentation of the region in front of this is at present merely a matter for conjecture.

The Position of the Eye.

The position of the eye seems to be very variable. In the early stages of development of many trilobites it is first seen on the margin. In later stages it shifts on to the dorsal surface, and in the adult it may be quite close to the glabella and to the posterior margin of the cephalon. These facts led Bernard[3] to regard the eye as a lonely wanderer on the face of the trilobite, and to conclude that it "had no fixed hereditary locus on the dorsal surface". But in other animals an organ that wanders usually takes a train of other organs with it, that is to say it retains its major morphological relationships. Thus the eye of the flat-fish, *Pleuronectes*,[4] wanders during development from one side of the head over the dorsal surface on towards the other side, but throughout its wandering it is accompanied by its full complement of muscles, nerves, blood-vessel, and bones. That is to say, it retains a definite position in relation to the general morphology of the head. Bernard unconsciously recognizes this fact for the trilobites when he says, "The eye never

[1] C. D. Walcott, "Middle Cambrian Brachiopoda, etc.": Smithsonian Misc. Coll., vol. lvii, pp. 192, 193, 1912.

[2] C. D. Walcott, "*Olenellus*, etc.": Smiths. Misc. Coll., vol. liii, p. 277, pl. xli, fig. 9, 1910.

[3] 1894, p. 420.

[4] *Vide* F. J. Cole & J. Johnstone, L.M.B.C., Memoirs, No. viii: *Pleuronectes*, pp. 174 et seq., 1901.

crosses the cephalic suture."[1] Had we spirit specimens to dissect we should no doubt find that the trilobite's eye maintained equally stable relations to the nerves, vessels, and other organs vitally connected with it. The position of the eye, then, is a definite morphological point.

When, therefore, every worker from Burmeister to Raymond in describing the trilobite organization states that *the facial suture passes behind the visual area and in front of the palpebral lobe, he is giving to that part of the facial suture a very precise position in the trilobitic anatomy.*

The Ecdysial Line in Mesonacidæ.

In the Mesonacidæ there is no fully developed facial suture on the dorsal surface. Rudiments occur occasionally. Nevertheless, these trilobites must have undergone ecdysis. As long ago as 1891 Walcott in describing *Callavia Broggeri* wrote: "It is a very common occurrence to find the 'doublure' on the reflected under margin lying free from the other parts of the head and with the hypostoma attached. This fact leads to the conclusion that a suture passes around near the frontal margin."[2] He mentions that a similar suture is described by Holm in *Holmia Kjerulfi*. In 1910 the same worker figures an interesting specimen of *Pædeumias transitans* (see Figure), which further substantiates these observations.[3] Raymond, referring to this figure, describes the detached portion of the doublure as "swung back so that it presents its ventral face to the observer on the same block with and still attached to the head-shield".[4] This fortunate find makes it possible to determine the morphological relation of this ecdysial line to the dorsal facial suture. Though no true dorsal suture is present the eye-lobes are well shown. If one imagines the doublure replaced in its original position it becomes evident that its line of separation from the remainder of the head-shield must lie either marginally or submarginally, and in any case morphologically, far distant throughout its length from the eye. That is to say, no fraction of it passes between the palpebral and ocular segments, and therefore that no fragment of it is homologous with that portion of a typical facial suture which takes this course. To homologize this line with the facial suture and the detached portion with the free cheeks is merely to cause confusion. For the purposes of this paper these may be called the marginal suture and doublure respectively.

The Ecdysial Line in Agnostidæ.

The Agnostidæ are blind and show no suture dorsally. Beecher believed that they possessed facial sutures and free cheeks on the ventral side.[5] Raymond claims to have found these in *Agnostus nudus*[6] (see Figure). Before applying the results of the above

[1] 1894, pl. 420.
[2] C. D. Walcott, Tenth Ann. Rep. U.S. Geol. Surv., 1891, p. 638.
[3] 1910, pl. xxxiv, fig. 6.
[4] P. E. Raymond, Amer. Journ. Sci., vol. xliii, p. 208, 1917.
[5] Amer. Journ. Sci., 1897, p. 183.
[6] Ibid., 1917, p. 198.

discussion to this case it should be noted that the region which he calls the cephalon in this species has hitherto been unanimously regarded as the pygidium. The only reason he advances for disagreeing so utterly with previous workers is that he has discovered structures like free cheeks on the ventral side of the "pygidium". Until he brings forward independent evidence to prove that the pygidium is not a pygidium, or that the ventral structures are free cheeks, his discovery cannot be regarded as valid. Meanwhile, all independent evidence seems to be against him, and his discovery seems to prove only that *Agnostus* underwent ecdysis by way of the pygidium.

It is of course possible that Raymond may yet prove his case. When he does that his further deduction[1] will be valid, viz., that the suture and ventral linear "free cheeks" he has found in *Agnostus* are "analogous" with the marginal suture and detachable doublure of *Pædeumias*. But this can only prove that they cannot be homologous with the dorsal facial suture and dorsal free cheeks of other trilobites.

The fact that the closely allied but distinctly more primitive genus *Pagetia*[2] has both eyes and true facial sutures indicates that Agnostidæ have lost both these features, and have reverted secondarily to a marginal ecdysial line. This point of view receives support, on the one hand, from a consideration of the extraordinary degree of specialization attained by the Agnostidæ in all respects, and on the other hand from the existence of indications of eyes and true facial sutures in the allied but much more primitive genus *Mollisonia*.[3]

The Ecdysial Line in the Trinucleidæ.

The problem of the facial suture in *Trinucleus* has been very fully discussed by Reed,[4] who concludes that the true facial suture has disappeared, that the free cheeks have fused with the fixed cheeks, and that the suture which is present along the margin has come into being secondarily. Raymond disagrees entirely with these conclusions, and regards the marginal suture and ventral free plates of *Trinucleus* as facial suture and free cheeks respectively.[5] He rightly homologizes these features with those which he claims to have discovered in *Agnostus*[6] and, by implication, with the suture and free doublure of *Pædeumias*. In other words *Trinucleus* has nothing which is homologous with the true facial sutures and free cheeks, and Reed's conclusions are proved to be correct by Raymond's own evidence. Moreover, though Reed finds no satisfactory traces of dorsal facial sutures, he does find eye-lines and vestiges of eyes. When these occur they do not show that association with the marginal suture which would prove this to be a true facial suture.

Orometopus, if it be related to the ancestral stock of *Trinucleus*,

[1] Ibid., p. 208.
[2] C. D. Walcott, Smiths. Misc. Coll., vol. lxiv, No. 5, p. 407, 1916.
[3] Smiths. Misc. Coll., vol. lvii, p. 195, 1912.
[4] Geol. Mag., 1916, p. 175.
[5] 1917, pp. 201 et seq.
[6] p. 203.

supplies proof positive that Reed is right. Raymond,[1] however, denies the relationship because *Orometopus* has compound eyes, large free cheeks on the dorsal side, less specialized glabella, more than six free thoracic segments, and a square hypostome. The first two differences, being the subjects of dispute, may be left out of account. The remaining differences are not differential characters, but are such as are usually looked for between the earlier and later members of a genetically related series. The type of argument he thus applies to *Orometopus* would prove that *Mæritherium* had no relationship to *Elephas*, or *Hyracotherium* to *Equus*.

Incorrect Usage of Embryological Evidence.

Agnostus and *Trinucleus* are the typical representatives of Beecher's *Hypoparia*, which was founded upon inferences drawn from the study of the development of many trilobites. In this it was observed[2] that the eye appeared most frequently upon the margin, and travelled backwards bringing the facial sutures and free cheeks with them as development advanced. The occurrence of this phenomenon in so many trilobites was taken to indicate that the ancestors had marginal eyes, marginal or sub-marginal facial sutures, and ventral free cheeks.

In coming to this conclusion sufficient care was not taken to test the value of the developmental evidence by a comparative study of the adult structure. The larvæ to which Beecher attached most importance have, in addition to the marginal position of the eyes, a glabella which increases in calibre anteriorly and often extends to or even beyond the front margin of the head-shield. Compare this condition with that found in such primitive adult trilobites as *Conocoryphe*, *Ptychoparia*, etc., which were known to Beecher, and *Nevadia*[3] and *Nathorstia*,[4] which have been discovered since he finished his work. In these adults the eyes when present are dorsal in position, the glabella diminishes anteriorly, and does not approach the frontal margin. When the facts of embryology clash thus with those of comparative anatomy the former must be interpreted with extreme caution.

The conditions prevailing in less primitive trilobites throws a flood of light upon the conditions in these larvæ. Thus an increase in the width of the anterior segments of the glabella is frequently exhibited by the more advanced members of a progressive series, cf. *Olenellus* with *Nevadia*. It can only be concluded that the larvæ which exhibit this feature are specialized also, at least, in this respect. Again, in such a series as *Cheirurus*, *Sphærexochus*, and *Deiphon* the forward extension and inflation of the glabella are accompanied by an assumption of other features, such as the marginal position of the eyes and curious isolation of the pleuræ, which according to Dollo point to a planktonic mode of life. The peculiarities of the glabella and the position of the eyes in the

[1] p. 203.
[2] Amer. Journ. Sci., 1897, p. 184.
[3] C. D. Walcott, Smiths. Misc. Coll., vol. liii, p. 256.
[4] Ibid., vol. lvii, p. 194.

protaspis of certain trilobites are therefore not to be regarded as ancestral features, but, more probably, as adaptive characters associated with a planktonic habit.[1]

If this be the true interpretation of the facts, then the backward shifting of the eye during development has no phyletic significance, but is merely associated with the cessation of the larval planktonic mode of life and the assumption of the benthic habits of the adult.

Beecher was unfortunate in his choice of developmental evidence upon which to base his opinions. Had he given more attention to the larvæ of the Mesonacidæ he would never have instituted the division *Hypoparia*. These larvæ retain traces of several pleuræ in the cheek region, and thereby show themselves to be the most primitive of all known trilobite larvæ and therefore the most valuable indicators of ancestral conditions. But even in the youngest of these larvæ known the eyes are dorsal and the facial suture is absent. This agrees with the evidence of the comparative study of the adult and therefore outweighs the perhaps more abundant evidence from more specialized larvæ.

Raymond falls into the same error[2] as his great teacher when he hints at the resemblance between the young of *Trinucleus* and the adult of *Agnostus* as evidence of affinity. A trilobite with such forms as *Harpes* and *Dionide* closely allied to it could not possibly have descended from an *Agnostus*-like ancestor.

The Trilobita are Monophyletic.

Raymond finds difficulty in accepting my interpretation[3] of Mesonacid structure and development because it implies that "the anterior segment was not oculiferous"[4] in them as in other trilobites, and that therefore trilobites must be polyphyletic. Why he should consider it necessary that the oculiferous segment must be the anterior one he does not state, but as long as there are to be found annelids such as *Hirudo* having eyes on every segment as far back as the fifth there is no need to postulate the first segment as the only one that can be oculiferous in trilobites. It has been shown above that the ocular segment is the sixth from the posterior margin in all trilobites which exhibit sufficiently abundant traces of segmentation to enable an opinion to be formed. Whether this is the anterior segment or not does not matter; the essential point is that the segment which bears the eye is the same for all trilobites, so that from this standpoint the order is monophyletic.

Conclusion.

The trilobites are a compact group, the members of which at first underwent ecdysis along a line which may be called the marginal suture. "To facilitate the removal of the covering of the eye in moulting"[5] dorsal facial sutures appeared independently in several distinct lines of descent. It is necessary to emphasize the fact that taken as a whole the true facial suture is composite,

[1] L. Dollo, *La Paléontologie ethnologique*, Bruxelles, 1910, pp. 406 et seq.
[2] p. 204.
[3] Geol. Mag., 1915, p. 492.
[4] Amer. Journ. Sci., 1917, p. 208. [5] Ibid.

being made up of a new dorsal portion intimately associated with the eye, and an anterior portion which is probably a section of the marginal suture. The posterior section of the latter seems to have been completely replaced functionally by the newly instituted line running behind the visual area. The whole of the marginal suture was liable to be resuscitated in forms which, like *Trinucleus*, became blind secondarily and thus had no special use for a dorsal suture.

The position of the marginal suture, whether primarily or secondarily instituted, lay somewhere in the vicinity of the margin of the cephalon. For the present it may be left as an unsettled point whether the suture seen near the margin in such blind forms as *Conocoryphe* and *Ampyx* is a true facial suture or a marginal one. The line of reasoning followed above points to the latter as the correct interpretation.

The theoretic implications of the name *Hypoparia* render it unsuitable for describing those forms in which a dorsal suture has not yet appeared, and in which the marginal suture is of primary origin; hence the introduction of the name *Protoparia* for these. The *Protoparia* cannot include *Trinucleus*, for that is a highly specialized, not degenerate Opisthoparian, neither can it include *Agnostus*, for that is an even more highly specialized Proparian. This being the case Raymond's suggestion that the terms *Hypoparia* and *Protoparia* are practically synonymous cannot be accepted.[1]

III.—Notes on Yunnan Cystidea. III. *Sinocystis* compared with similar Genera.

By F. A. Bather, D.Sc., F.R.S.

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(PLATE III.)

B.—Comparison with *Megacystis* (*continued*).

3. *Structure of the Pores in Megacystis.*

Essentially the pores of *Megacystis* are diplopores, for they are arranged in pairs. This is evident on the inner surface of a plate (E 16169, E 7671). Here each pore-pair lies in a shallow depression, and each pore again lies in a slight depression at the bottom of this (fig. 14). Compare *Sinocystis yunnanensis* (*antea*, p. 538).

From these inner openings the pore-canals pass outwards through the meso-stereom, still retaining their paired character. This can be traced in vertical sections, since the canals as a rule follow a fairly straight course normal to the surfaces; but it is more easily seen in horizontal sections of a plate (E 7675), or in the naturally worn surfaces. For instance, E 16169 shows the ω-channels in only a small region, while the remaining surface is worn, with the result that the structures manifest all over the theca appear to be ordinary diplopores. This effect is particularly obvious when the pore-canals have been filled with a dark matrix (e.g. E 7644, E 7641). Sometimes the matrix has been dissolved out, leaving the canals empty (E 16171).

[1] 1916, p. 209.

An outer surface that has been slightly worn, so as to uncover the ω-channels without obscuring them, shows the outer openings of the pore-canals connected by shallow channels on the following plan (fig. 15). The simplest arrangement consists of two channels, curved like the sides of an O, with a pore at each end. Next comes a doubling of these channels. Both of these arrangements are well shown near the base of E 7676 (fig. 16). It appears as though the doubling were due to, first, a broadening of each channel, and, secondly, a median up-growth of its floor. This process may take place on one side only, so as to yield a total of three channels; or it may be repeated on one side, yielding five channels (fig. 15), or, very rarely, on both sides, yielding six.

It is, however, unusual to find quite so simple a pattern: modifications arise in two ways. First, by simple irregularity in the curves of one or more channels. Secondly, by other up-growths of the floor so as to bar one or more channels (fig. 17). Each of these modifications seems to be subject to a special limitation. The irregularity is subject to the bounds which are set to the channel-system of a single pore-pair. The barring is subject, apparently, to the condition that such a channel-system must be continuous; thus, no part of a channel has been observed with a bar at each end; however irregular the labyrinth may become, it is always possible to track along every part of it.

Now as to the bounds of a channel-system. In no case does a system transgress the boundary of a plate; no pore-canal, and no channel, ever crosses a suture. Within each plate the diplopores are distributed over the whole surface—not regularly or according to any pattern, but at approximately equal distances. There are two plans of structure: the diffuse (figs. 16, 17, 18) and the concentrated (figs. 19, 20, 21). In the former the channel-system is diffuse and is separated from adjoining systems by a tract no wider than a single channel or, what comes to the same thing, no wider than a ridge between two channels. No wider is the space left at the sutural margin. Each channel-system spreads itself out until brought up against its neighbours; and, since the foci of each system are distributed irregularly, the boundaries also become irregular; did the systems start from equally-distributed centres, their boundaries would form regular hexagons, but, as it is, they form irregular polygons. It is therefore not easy to distinguish these boundaries from the other ridges, and so the whole thecal surface appears at first sight covered with a confused maze of channels. It seems possible that this complexity has misled even so acute an observer as Professor Jaekel (1899). His plate iv, fig. 2*a* shows in some cases as many as 5, 6, or 7 pores belonging to the same channel-system. There may in rare cases be more than one pore-pair to a system, but I am not convinced even of that. What does often happen is that the outer opening of one (or both) of the pores is crossed by a bar (fig. 17), so that externally the pore seems duplicated or even triplicated. There is also a deceptive appearance of pores at other bars.

Finally, the pores and their connecting channels are covered on the

outer surface by a thin epistereom, so that on a well-preserved surface they are at first invisible, and all that one sees is the finely-vermicular ornament of the epistereom (E 7633). If, however, the surface be wetted, it is usually possible to see the channels beneath, looking much like the tunnels that a boring sponge or alga makes between the layers of a mollusc shell (fig. 18). The manifestation of the buried channels is generally increased by the fact that they are injected with a fine mud, which has reached them through the pore-canals from the interior of the test. It does not seem possible to explain the appearances as due to anything other than a complete coating of stereom. In thecas with diffuse channel-systems, the outer surface, when well-preserved, is equable and smooth, except for the fine ornament.

In thecas with concentrated channel-systems, the outer surface is raised into a little pustule over each system (E 7629. E. 7672, E. 7673, see fig. 19). When slightly worn, the ends of the channels are opened up and look like so many pores on the surface of the pustule (fig. 20). Further wearing shows that in every case there is only one diplopore to each pustule (fig. 21). Thus, Miller writes of *H. ornatus* (1878, p. 132): "Surface . . . pustulose . . . The pores open upon the summit of the granules, and where the granules are worn off, the plates show the pores, in pairs, passing through to the interior." So also of *H. splendens*, Miller & Gurley write (1894, p. 7): "The whole body is pustulose and every pustule is pierced by a pair of pores."

These pustules with their appearance of many pores may be compared with those vesicular multiperforate tubercles in *Caryocrinus*, of which so admirable an account was given by James Hall (1852, Palæont. N.Y., vol. 2, p. 220). There a single pepper-box pustule, as one may term it, may have as many as six outer openings, but only one pore-canal leads to the inner surface of the thecal plate. In older specimens the pustules of a single row enlarge till they coalesce, "forming a vesicular ridge."

The various modes of preservation and the differing amount of weathering produce a number of diverse appearances in these two plans of structure. Besides those already alluded to, one notes that in the diffuse pattern weathering frequently affects the area of the channel-system more than its boundary, so that the latter stands up as a ridge; possibly it is actually of denser stereom than the channelled area. On the other hand, the injected material may be more resistant than the stereom, and in this case the channels, and especially the pore-canals, stand out while the surrounding tract is weathered away. In some cases this eventually produces an irregular pustulation (E 7630), which must not be confused with the true surface-pustulation of the concentrated plan. It is plain that the thecas were often lying for some time on the sea-floor, and that their surface was then worn and overgrown in part by bryozoans and other incrusting organisms. When fossilization took place the open channels formed a key for the matrix, which ultimately became firmly bound to them by secondary calcification. In such cases the pattern shows up in sinuous ridges of pale

light-reflecting matrix on the darker light-absorbing stereom, and it is hard to believe that these ridges really represent channels once covered by epistereom.

Even when one's mind is clear as to the facts, it is not easy to understand the origin of the channel-systems. There are two features to be explained: first, the number and sinuous extension of the channels; secondly, their closure by epistereom. The simplest pattern, as Professor Jaekel points out (1899, p. 413), seems but a modification of a single oval peripore[1] (Höfchen); when the outer covering is worn away, there is indeed little difference apparent. The channels connecting the two pores correspond to the moat of the peripore (fig. 16). How or why did they become covered? The answer to that question might also furnish the clue to their multiplication. To one who, like Prof. Jaekel, believes that the normal diplopore was covered (*antea*, p. 513), there should be no particular difficulty. Now the diplopore is obviously a complete unit. If it had a roof of epistereom, the development of a channel-system would take place by the union of the periporal floor with the roof—first between the two pores, leaving a channel on each side; then along the floor of each channel, thus splitting it into two; and so on. It is assumed by this hypothesis that the channels as they multiplied would move apart, at all events in the case of the diffuse pattern. This explanation is beautifully simple, but it provides no motive force. A diplopore seems so finished a structure, so obviously adapted to some function or other, that one cannot imagine why in this limited genus it should become broken up in this way.

Let us now suppose that the diplopore was not originally roofed over. The natural interpretation then seems to be that the pore-canals served to bring fluid (probably cœlomic) into osmotic connection with the surrounding medium, and that the fluid passed out by one canal and in by the other. The combined tube probably extended as a papula, and for the base of the papula the peripore afforded an attachment suggestive of retractile muscles. We have seen in *Sinocystis* how the central region of a diplopore is raised into a pustule, attaining sometimes considerable height. This implies deposition of stereom in the walls of the papular tube. Excess of deposition would interfere with the assumed function of the papula, and might lead to the closure of the pores, as Dr. Reed believes to have been the case. This calcification of the wall, with consequent reduction of the osmosis, would have to be counteracted, and that can be effected only by increasing the surface. Here then is the motive for the multiplication and extension of the channels. In the case of pustule-formation, the channels seem to have remained close round the original pustule, producing the concentrated plan. The diffuse plan can not have been preceded by pustule-formation, and we must suppose the calcification to have taken place round the margin of the peripore more rapidly than in its central area.

[1] The term "peripodium" was extended to these structures by Lovén (1883, Pourtalesia, p. 57), since he believed that tube-feet sprung from them as from the similar structures in Echinoidea. It seems advisable to drop this use of the term, along with the belief that it implies.

There is yet a third hypothesis. By placing his *Trematocystis* with *Aristocystis* in a family Aristocystidæ, Dr. Jaekel implies that the channel-systems were derived from the irregular groves of the latter genus. He says in effect:—In this family of *Diploporita* the peripores are lengthened in worm-fashion and form closed respiratory spaces beneath the epistereom. In *Aristocystis* the epistereom shows a smooth surface, and the pores are not visible till this is removed. They are then seen to be connected by irregular channels—the elongate peripores—and each channel may include two or more pores. One of Jaekel's drawings (p. 409) shows as many as four pores, three at the ends of a Y and one at the fork. One of Barrande's figures (1887, pl. 38, fig. 23) shows six pores in a channel. In *Trematocystis*, Jaekel continues, this tubular elongation of the peripores led to their duplication and combination, while the mesostereom also shared in their envelopment.

It is not quite easy to follow this account. In the first place there is still room for scepticism concerning the covering of epistereom. The outer layer seen in many of these Bohemian fossils has not yet manifested any structure, and may be nothing more than an adherent film of limonite induced by the decay of the organic stroma. Secondly, the account implies that the channel-systems of *Trematocystis*, or at any rate the more complicated ones, involve more than two pores; as already stated, I am unable to confirm this. Thirdly, the interposition of the peculiarly irregular stage represented by *Aristocystis bohemicus* between the normal diplopore and the simplest system seen in *Trematocystis* raises a gratuitous difficulty, and one apparently inconsistent with Jaekel's own comparison of the two latter.

Possibly Jaekel had in mind (though he did not mention them) the channel-systems of *Hippocystis* (*antea*, p. 72). There is an obvious resemblance between an omega and two horseshoes set side by side with the adjacent ends meeting in a single pore. But closer scrutiny of the facts renders it doubtful whether a system of this pattern is ever found in either *Megacystis* or *Hippocystis*: in the former, if the pattern resembles an omega, it is with a difference, and there are two pores to the system, not three; in the latter the horseshoes neither meet nor overlap, so far as one can judge from Barrande's figures and description. It is therefore no easier to derive the *Megacystis* system from that of *Hippocystis* than from any simple diplopore.

On the whole the second of the three hypotheses here discussed seems best to harmonize the various views that have been expressed as well as the greater number of the structural facts. The idea that the assumed papulæ tend to be calcified is confirmed by the lofty pore-pustules of *Sinocystis loczyi* and the pore-turrets of *S. yunnanensis*. The supposed clogging by excess of calcification is confirmed by the pepper-box pustules of *Caryocrinus ornatus*. Two large tubercles of similar nature appear, as a result of individual and local hypertrophy, in the holotype of *Megacystis hammelli* (Miller, sub *Holocystites*). Whether the elongation and sinuosity of the peripores in *Aristocystis* was due to a similar need for extending the respiratory surface, cannot be decided. At any rate the channel-

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PORES AND CHANNEL-SYSTEMS IN MEGACYSTIS.

16, 17, 18, Diffuse plan. 19, 20, 21, Concentrated plan.

All figures enlarged 20 diameters.

systems of *Megacystis*, each with its single diplopore, do not seem like direct modifications of the *Aristocystis* plan. It is curious that this type of channel-system should, to all appearance, have been confined to a single arm of a single sea during one relatively brief period of the earth's history.

EXPLANATION OF PLATE III.

PORES AND CHANNEL-SYSTEMS IN MEGACYSTIS.

FIG. 14.—Openings of two diplopores on the inside of the theca in E 7671.

,, 15.—Three diagrams to show the multiplication of the channels from (*a*) the primitive two, through (*b*) four, to (*c*) five.

,, 16.—Simple channel-systems, corresponding to stages *a* and *b* of Fig. 15, seen in E 7676.

,, 17.—A portion of the worn thecal surface in E 7639, showing more complicated channel-systems. In *a* the two pores are distinct, but there is a deceptive appearance of a pore where the short channel ends on a bar. In *b* the pore to the right is divided by a bar. In *c* both pores are so divided.

,, 18.—A portion of the unworn thecal surface of E 7633. Two channel-systems are faintly seen beneath the epistereom.

,, 19.—A portion of the unworn thecal surface of E 7673, showing pustules. Here conditions of petrifaction are such that the underlying channels can nowhere be detected.

,, 20.—Pustules in various stages of weathering; from the deceptive appearance of many pores, through the exposure of the channel-system, to the beginning of its disappearance. Selected from E 7629.

,, 21.—Other stages in the wearing down of the pustules till the primitive diplopore is exposed. Selected from a single plate in the theca of E 7672.

The figure-numbers continue those of the text (Nov. and Dec., 1918).

All figures enlarged 20 diameters.

IV.—NOTES ON AMMONITES.

By L. F. SPATH, B.Sc., F.G.S.

III.

IN addition to the variability of the suture-line in a given species, mentioned previously, asymmetry of the elements on opposite sides of the same suture-line is very frequent and probably universal in so far as the minor frillings are concerned, which is only to be expected in organic beings. This phenomenon has lately been illustrated again in *Lioceras* by Horn,[1] and in *Dactylioceras* by Swinnerton & Trueman.[2] The latter authors also have some interesting observations on asymmetry associated with lateral displacement of the siphuncle which is of sporadical occurrence in Ammonites.

Canavari[3] had noticed that in some Spezia forms the siphuncle was asymmetrical in the young and then became central; and Solger[4] records a familiar excentricity in *Hoplitoides*. The

[1] "Die Harpoceraten der Murchisonæ-Schichten d. Donau-Rhein Zuges": Mitt. Grossherz. Bad. Geol. Land. Anst., vol. vi, pt. i, p. 264.

[2] Op. cit., Q.J.G.S., vol. lxxiii, pt. i, pp. 40, 51, 1917.

[3] "Beitr. z. Fauna d. Unt. Lias v. Spezia": Palæontographica, vol. xxix, pt. iii, p. 192, 1882.

[4] "Fossil d. Mungo-Kreide": Geol. v. Kamerun, ii, p. 217, 1904.

asymmetry here is lost when the venter becomes acute. On the other hand, when dissecting a specimen of, e.g., *Psiloceras erugatum* (Bean-Phillips) with asymmetrical suture-line it is found that on the innermost whorls the suture-line is quite normal and that the position of the siphuncle (and of the ventral lobe) shifted gradually away from the median plane, thus causing unequal development of the opposing halves of the suture-line. Swinnerton & Trueman remark that usually only the ventral features are affected, and enumerate many genera in which this sporadical displacement has been noticed.

These authors also point out that nearly every specimen in which this type of asymmetry has been noticed has a rounded or flat venter. The most notable example of the round-ventered shells is *Psiloceras*, several signs of instability in which have already been noticed. On a previous occasion [1] the writer attempted to demonstrate the *Monophyllites-Mojsvarites* ancestry of this genus, and in this original stock asymmetry apparently is unknown. In the Yorkshire representative *Psiloceras erugatum*, a particularly variable species-group, asymmetry may be associated with close or distant septation, or may be absent altogether. Again, there may be approximation of the last two to six septa or no approximation at all, with or without "reduction". The specimens are also generally smaller than the Somerset equivalent *P. planorbis* (Sowerby), which unfortunately is always squashed, or the Wurtemberg *P. psilonotum* (Quenstedt), and the Yorkshire examples remind one of the dwarf-forms of the Hierlatz, so that one might be tempted to compare them with organisms living under unfavourable conditions, such as the shells in the brackish waters of the Baltic. But the enormous development of the genus *Psiloceras* in the Alpine Hettangian, where asymmetry is very common, shows that it was a dominant and thriving stock. It may be assumed that there was a great "burst" when, with the extension of the sea over wide new areas, the Ammonites which in the Rhætic had nearly become extinct, were able to spread again. The one surviving family Phylloceratidæ, reduced to a few secluded localities of the Alpine Rhætic Sea, entered upon a new phase of development, and in its principal first Liassic descendant *Psiloceras* showed a strong adaptive radiation.

It might be asked whether this could not have affected the position of the siphuncle, and therefore the suture-line, in an attempt to change a bilaterally symmetrical swimmer into a crawling benthonic organism. For, as has already been pointed out, its probably nectonic contemporary *Phylloceras* (which, like the somewhat later "*Rhacophyllites*", *Euphyllites*, *Parapsiloceras*, *Pleuracanthites*, and *Analytoceras*, never migrated beyond the Alpine Hettangian Sea) does not show these signs of instability.[2] Diener, who thinks the

[1] L. F. Spath, "On the Development of *Tragophylloceras Loscombi*": Q.J.G.S., vol. lxx, p. 352, 1914.

[2] Canavari (op. cit., 1882, p. 69) has thought that asymmetry of the suture-line was not found in Phylloceratidæ, but he figures as *Amaltheus* (*Sphenodiscus*) *sinister* (ibid., pl. ii, xvi, fig. 17*a–c*) a form of "*Rhacophyllites*", that clearly shows this asymmetry; and both Pompeckj, and Swinnerton and Trueman mention it as occurring in *Tragophylloceras*, but these are not typical

asymmetry of no biological importance, would look upon such forms as "*Psiloceras*" *abnorme* (Hauer), "*Psiloceras*" *Suessi* (Hauer), and *Oxynoticeras Janus* (Hauer), as small forms, with limited geographical distribution, and probably adapted to a crawling mode of life.[1] The first two, in which apparently the asymmetry is fairly constant, are comparable to *Psiloceras*, with which genus, however, they cannot be united. The last, where the ornament also is affected, has a counterpart in *Amaltheus paradoxus* (Stahl), though here the suture-line may also be normal, and it seems that Diener's suggestion of a crawling mode of life may hold good for these abnormal forms. In helicoid shells that must be explained in this manner, the position of the siphuncle apparently is not affected, however.

In a round-ventered shell the position of the siphuncle in the median plane is, of course, not essential; and the functions of the indented septal edge, both as a strengthening feature and as a means of attachment of the animal to its shell, would not be interfered with by an unsymmetrical arrangement. It may be assumed that *Psiloceras*, though a dominant and thriving genus, was comparatively unstable owing to the instability of its conditions of existence. Neumayr[2] drew attention to this instability, and pointed out the variability of the Alpine *P. (calliphyllum* species-group) forty years ago, and Rothpletz[3] shows that even in a locality where there is a continuous transition from the Rhætic Kœssen beds with *Mojsvarites planorboides* to the variegated limestone facies of the *planorbis*-zone (Marmorgraben, near Mittenwald, Bavarian Alps), only brachiopods and lamellibranchs are found in the first six to twelve feet of Lower Liassic marls. Asymmetry of the suture-line in *Psiloceras* may then be looked upon as an abnormality that had attained a considerable degree of constancy, but which was due to constitutional instability. This was eliminated when an exceedingly strong radiation with production of keeled and grooved forms (both keel and groove being in part protection of the siphuncle) took place.

In the case of flat-ventered shells, such as *Hoplites splendens*, Swinnerton & Trueman think that "asymmetry is probably a growth-phenomenon associated with the tendency of the siphuncle to take up

Phylloceratids. It may be suggested for e.g. *Meneghiniceras* and other "*Rhacophyllites*", that, like many modern marine organisms, they were pelagic in the young and littoral when adult.

The form figured by Canavari affords a good illustration of the unsatisfactory results of a morphological classification of Ammonites according to the adult suture-line. Canavari wrote: "A remarkable circumstance in this species is the presence of three lateral lobes. Thus it lets itself be grouped in section B of the Amaltheids, according to Neumayr & Uhlig, which comprises the forms with three or more lateral lobes, and perhaps in the sub-genus *Sphenodiscus*, Meek, with complicated lobes." In 1888, Canavari ("Contribuzione alla Fauna del Lias inferiore di Spezia": Mem. R. Com. Geol. Ital., vol. iii, pt. ii, p. 34) assigned this form to the genus *Oxynoticeras*, but its suture-line shows it to be a Rhacophyllitid.

[1] Op. cit., 1912, p. 81.

[2] "Zur Kenntnis d. Fauna d. Unterst. Lias i. d. Nordalpen": Abh. k.k. Geol. Reichsanst., vol. vii, pt. v, p. 25.

[3] "Das Karwendelgebirge": Zeitschr. d. D. O. Alpenvereins, vol. xix, pp. 427–8, 1888.

a stable position along the angle bounding the venter".[1] Among Pseudoceratites, e.g., *Protengonoceras* and *Heterotissotia* belong to this group, and *Hoplitoides* in the young stage, though here the development of an acute venter in the adult causes the disappearance of the excentricity of the siphuncle. Solger saw an adaptation to a benthonic existence in the latter, but the great variability shown in the thirty-five specimens of *Hoplitoides*, quoted by Solger, points to unstable conditions. This author also adduces the reduction of the suture-line, the local restriction of the genus *Hoplitoides*, his discovery of a specimen with several destroyed air-chambers, and the similarity to the Triassic *Ceratites*, as evidence for the adaptation to a benthonic existence. The writer has already given his opinion on the first and third points, and the second does not now apply since *Hoplitoides* has been found, e.g. in Tunis (Pervinquière). With regard to the likeness of the Pseudoceratites of the Cretaceous to the real *Ceratites* of the Trias, Phillipi's conclusions on which Solger's theory of adaptation to a benthonic mode of life for both was based, have also been disproved (Diener).

Asymmetry in oxynote shells is very rare, and Swinnerton and Trueman mention that they have not detected one case of asymmetry in specimens with keeled venters (p. 54). The most notable example is *Garnieria heteropleura*. Neumayr & Uhlig[2] examined about fifty specimens of this and found the siphuncle excentric in each. It may be assumed that the function of an oxynote venter was, primarily, to assist rapid motion through the water, and only secondarily to act as protection for the siphuncle, which in an unstable stock might vary its position slightly, especially if the keel be hollow. Though this last case is doubtful, however, the writer is inclined to think that asymmetry of the siphuncle and suture-line cannot, by itself, be taken as sound evidence in favour of adaptation to a benthonic, crawling existence.

In connexion with a pathological or accidental case of asymmetry in a Perisphinctoid form, where the dorsal as well as the ventral features of the suture-line are affected, Swinnerton & Trueman refer again to the gas-pressure which, in Ammonites, was assumed to have been strong enough to impose upon the septum a marked convexity. They state (p. 52): "If this [septum-secreting area of the mantle] became hypertrophied on one side, it would still assume the form of a stretched membrane, but being more resistant to pressure from behind, would not become so concave forwards as the other half." And on p. 37 the authors suggest that the second septum of *Dactylioceras* already must have been formed under the influence of that pressure, though at the time of formation of the protoconch and even of the first septum, the mantle was strongly convex.

Brief allusion to this pressure has already been made in connexion with the phylogenetic "reduction" of the suture-line; but in Pseudoceratites, where the simplification is said to have been carried to such extremes, the septum is still convex forwards. It seems to

[1] Op. cit., p. 55.

[2] "Über Ammon. a. d. Hilsbild. Nordd.": Palæontographica, vol. xxvii, pp. 135–6, 1880–1.

the writer that the internal pressure of air, gas, or aerated fluid in Ammonoids need not have differed from that in Nautiloids of a corresponding type of shell and mode of existence, that it depended on the depth at which the septum was formed, i.e. external pressure, and that the differences in the position of the siphuncle, in the thickness of the shells, and in the methods of attachment, determine the shape of the septum. Mr. Crick [1] has shown that "not only was the Ammonoid animal, like the *Nautilus*, at least at some periods, attached to its shell by means of the lobes and saddles of the posterior portion of the body—corresponding to those of the edge of the septum of its shell—but it seems . . . that it was further provided with an annulus in addition to shell-muscles, as in the recent *Nautilus*. It would appear, therefore, as if the provision of an annulus were an absolute necessity to the animal in addition to the shell-muscles, and most probably Dr. Waagen's explanation of its occurrence is the correct one, viz. that the annulus and shell-muscles served not merely to hold the animal to its shell, but formed also an air-tight band around it, fastening the mantle to the shell." Since the muscles could probably easily become detached, as in *Nautilus*, it may be assumed that the protrusions of the mantle that went into the lobes tended to strengthen their adherence to the septum by progressive backward penetration of their fibres, thus causing the convexity of the septum. In a cylindrical shell like *Lytoceras*, where the elements radiate from the centre of the septum, the lobes would attach themselves more or less equally all round the shell-wall, and the more complex the septal edge the firmer the attachment. Such progressive complication is shown, e.g. in the first lateral lobe of the *Androgynoceras Henleyi–Bechei–nautiliformis* series, and on the other hand it has already been suggested that, on the adaptation to a benthonic existence in such forms as *Cochloceras* or *Rhabdoceras*, extreme simplification of the suture-line may result; for in these the need for firm attachment of the animal to its shell, while muscles and annulus shifted forward after completion of a new septum, was probably less great than in an active swimmer.

It has already been mentioned that "the tortuous windings of the foliated margin of the transverse partitions . . . strengthened the shell of Ammonites".[2] Buckland [3] examined at great length the "proofs of contrivance and design". Apart from the "use of giving

[1] "On the Muscular Attachment of the Animal to its Shell in some Foss. Ceph. (Ammonoidea)": Trans. Linn. Soc., vol. vii, pt. iv, p. 109, 1898.

[2] R. Owen, *Lectures on the Compar. Anat. and Physiol. of the Invertebr. Anim.*, 1843, p. 331.

[3] "Geology and Mineralogy, etc.": Bridgwater Treatise VI, vol. i, sect. iii, "Nautilus," pp. 310–32; sect. iv, "Ammonites," pp. 333–57; also sects. v and vi, pp. 357–60; and vol. ii, pp. 58, 59, 62.

This author (p. 62, vol. ii) also stated that the "course of the transverse plates was beneath the depressed and weakest part of the external shell, avoiding the bosses . . . which from their form were strong". This is not borne out by the specimen of *Hoplites auritus*, figured by Swinnerton and Trueman (op. cit., pl. iv, fig. 8), and it seems that in general the septal edge is independent of the position of the tubercles, which are also often irregularly spaced.

strength to the shell to resist the pressure", the "further use suggested by von Buch of affording points of attachment to the mantle", showed to him "the union of two beneficial results from one and the same mechanical expedient". Zittel[1] and Uhlig[2] held that the strongly ramified borders of the septa serve to increase the solidity of the shells, and the latter author showed (for *Lytoceras*) that "as the whorls only just touch one another they could offer little mutual support, and therefore every increase of resistance, if only slight, must have been of great value. Thus, physiologically, the sutural lobes would have served the same purpose that was attained in another genus with very evolute whorls, *Arietites*, by the external keel with its two accompanying grooves". It may be pointed out here that the septal surface, with excentric siphuncle, in both Ammonoids and Nautiloids, in spite of its anterior and posterior folds, is nearly enough at right angles to the whorl-surface to act as a strengthening feature. In the adult septum of *Dactylioceras*, fifty-two per cent of the area of the septum lies between contours only ·75 mm. apart, according to Swinnerton and Trueman (p. 32); and their graph shows that the area of the posterior folds is not much greater than that occupied by the anterior folds, i.e. that the convexity is comparatively slight.

In Nautiloids, provided with a simple suture-line, the shell in general is considerably thicker than in Ammonoids, where, ordinarily, it is "as thin as paper".[3] Diener[4] writes: "The shells of Phylloceratidæ, Perisphinctidæ, and Arcestidæ are always delicate, smooth shells of thickset build, more delicate than the *Nautilus* shell; Lytocerates are often as thin as paper and clear as glass, with feeble ornament." Boehm[5] found that the shells of *Nautilus*, washed up on the shores of the Sula Islands, were thicker than most Callovian Ammonites. On the other hand, the formation of septa by the nacreous layer of the shell and the periodical repetition of these during the progress of growth, concurrently with the formation of new layers which extend and expand the mouth of the shell, was probably the same in normal or irregularly coiled Ammonoids, as in the ancestral cyrtocone[6] or the present-day *Nautilus*. The material

[1] Op. cit., 1881–5, pp. 332 ff.

[2] "Die Cephalopoden Fauna d. Wernsdorf. Schichten": Denkschr. d. Math.-Naturwiss, Cl. d. k. Akad. d. Wiss., vol. xlvi, p. 61, Vienna, 1883.

[3] Op. cit., p. 332.

[4] Op. cit., 1912, pp. 67–89.

[5] "Beitr. z. Geol. v. Niederländ. Indien": I, 4, Palæont. Suppl. IV, 1912, p. 173.

[6] Whether the earliest representatives were active benthonic animals or attached and sedentary, is not known. But it is probable that from the ancestral capulicone, cyrtocones and orthocones arose, with elongation of the shell after the manner of tubular structures in Actinozoa, Polyzoa, Annelida, and Gastropoda ("Guide to the Fossil Invertebrata Animals in the Department of Geol. and Pal. in the Brit. Mus. (Nat. Hist.)," 1907, p. 147), and the formation of septa at the end of the cone only after a continued period of elongation and pulling away of the visceral hump from the cone, probably to give it buoyancy. But orthocones and cyrtocones cannot have been active swimmers. (See the interesting paper by O. Jaekel, "Thesen üb. d. Organis. u. Lebensweise ausgestorbener Cephalopoden": Z.d.g.G., vol. liv, p. 67,

of which the Ammonite septum was composed was probably of the same character and the same strength per unit cross-section as it is in the living *Nautilus*, and similarly deposited on a conchiolin membrane, starting in the region away from the siphuncle. Pfaff[1] found that in many well-preserved Gault Ammonites the pearly substance was quite similar and showed an identical structure of more or less parallel thin lamellæ, as in the septum of *Nautilus pompilius*. This author also shows in detail how in the case of *Nautilus* where the septa are concave forwards, as well as in Ammonites, external excess pressure would be transferred to the shell wall; and he comes to the conclusion that the arched septum of Ammonites need be only one-sixth of the thickness of the septum of *Nautilus*. But Pfaff[2] further assumes that one reason why the suture-line of *N. pompilius* is only curved as compared with the highly ramified suture-line of Ammonites is the thickening of the end-septum of the former. This is improbable, however, for as all the previous septa were capable of withstanding the external excess pressure, there was no need to thicken the last one, and it seems to the writer that this thickening is on a par with the occasional approximation of the last few septa when the animal had reached its full growth.

In *Nautilus* the siphuncle occupies exactly the centre of the supporting septal surface, though, as Dr. Foord has pointed out,[3] a change of position of the siphuncle during ontogeny is of frequent occurrence in fossil *Nautili*. The central siphuncular structure of these acted not only as a strengthening feature, as suggested already in 1854 by Pictet,[4] who thought it probable that in Ammonoids the complicated septa "were necessitated by the excentric position of the siphuncle", but the siphon also afforded an additional means of attachment.[5] In primitive Goniatites the earliest few septa are concave, and it has already been stated that the second septum of e.g. *Dactylioceras* also tends to be concave and is similarly associated with a simple suture-line and a sub-central siphuncle. When it is further found that e.g. in the Carboniferous *Subclymenia evoluta* (Phillips), the Triassic *Clydonautilus goniatites* (Hauer) or the Upper Jurassic *Pseudonautilus Geinitzi* (Pictet) a nearly external siphuncle is associated with an angular suture-line, it seems, indeed, probable that the shifting of the siphuncle to the external side first started the differentiation and convexity of the septal surface.

1902; also R. Ruedemann, "Structure of some Primitive Cephalopods": Report of New York State Pal. 1903, p. 334, for *Piloceras*.) They were probably benthonic, and it was only after the shell had become coiled upon itself and bilaterally symmetrical, that the Cephalopod animal could adopt a freely swimming mode of life.

[1] "Über Form und Bau d. Ammonitensepten und ihre Bezieh. z. Sutur-Linie": 4. Jahresber d. Niedersächs. Geolog. Ver., 1911, p. 212.

[2] Op. cit., p. 212.

[3] *Cat. of Foss. Ceph. in the Brit. Mus.* (*Nat. Hist.*), pt. ii; Nautiloidea, 1891, p. 322.

[4] *Traité de Paléont.*, vol. ii, pp. 666–7.

[5] Older authors (e.g. Vrolik & Van Breda, Ann. Mag. Nat. Hist., vol. xii, p. 173, 1843) even held that the animal was attached to the shell only by the siphon.

The writer would like to draw attention in this connexion to the interesting series of *Nautili* from the London Clay, which shows the close interconnexion of the various mechanical features of the shell. *Nautilus Parkinsoni*, Edwards, which has *Aturia* lobes (but the siphuncle farther away from the dorsum than e.g. the galeate-whorled *N. Sowerbyi*, Wetherell, with only slightly undulating septal edges) lacks the wide trumpet-mouthed funnels of typical *Aturiæ* where the siphuncle is dorsal. It might be suggested that apart from its connexion with the attachment of the animal to its shell, the differentiation of the septal surface in the neighbourhood of the siphuncle would afford protection for the latter. This would apply especially to the typical Ammonites in which elaboration of the suture-line begins at the siphonal lobe and progresses dorsally as is shown, e.g. in fig. 9 (p. 42) of Swinnerton & Trueman's paper, and in which external features such as a keel or a groove are similarly interpreted as contrivances for the protection of the siphuncle. It is probable, however, that this is partly also a case of retention of an original feature and gradual elaboration of the first ventral lobe or siphonal collar of the Goniatite radical, in such a manner that in a later Ammonite, e.g. the external saddle of stage 1 = the first lateral saddle of stage 2 = the second lateral saddle of stage 3 = the first auxiliary saddle of the (latest) stage 4.[1]

Pfaff[2] states that "as during growth the septal surface increases at the relatively quickest rate on the external side, differentiation must begin here". But in that case Clymenidæ, with an internal siphuncle, should not show greater elaboration of the suture-line on the dorsum. Here, also, protection for the siphuncle would have to be assumed, and the abnormal position of both siphuncle and deeper lobes suggests derivation of this stock, not from *Gyroceras* as Frech thinks, but from a Goniatite ancestor with a siphuncle, the position of which may have been unstable (as in the early whorls of most latisellate Ammonoids) but which had already become associated with the region of greatest differentiation of the septal surface.

It is necessary to distinguish between the progressive elaboration of the suture-line in the whole order Ammonoidea and the differentiation in certain stocks necessitated by e.g. whorl-shape. The *Dimorphoceras–Thalassoceras* lineage, e.g., seems to be the first one in which the minor details of the ventral lobe are elaborated, and from *Pronorites* onwards, and especially during the Permian and Lower Trias, first the lobes and then the saddles of all the stocks show progressive frilling. On the other hand, in more specialized lineages, such as the Devonian *Beloceras*, already differentiation is most pronounced in the lateral region, though it begins with the primitive ventral lobe. This applies to practically all compressed Ammonoids, as has already been stated, and demonstrates the impossibility of a morphological classification that groups together the above Devonian *Beloceras* and the Upper Triassic *Pinacoceras*, simply because these heterochronous homœomorphs possess a compressed shell.

[1] See L. F. Spath, Q.J.G.S., vol. lxx, fig. on p. 341, 1914, stages *e*, *f*, *h*, and *l*.
[2] Op. cit., p. 222.

V.—Pleochroism in a Tin-bearing Mineral from Siam.

By J. B. Scrivenor, M.A., F.G.S.

In 1915 a heavy concentrate of sand from an unknown locality in Siam was submitted to me for identification. The sand consisted of rather coarse grains of a dark mineral, and finer grains of ilmenite, monazite, tourmaline, zircon, and topaz, with some of the same dark mineral as that occurring in coarse grains.

The dark mineral was isolated and examined by partial chemical analysis and by optical methods, the results proving that it was a tin-bearing mineral with a remarkable pleochroism. The specific gravity was found to be 6·913.

The chemical examination, carried out by Mr. C. Salter, gave the following constituents: Sn, 74·50 per cent; TiO_2, 0·17 per cent; and some iron and alumina. Metallic tin was readily obtained on fusion with KCN.

Optically the mineral was found to be uniaxial and positive, and it exhibited a very marked pleochroism of deep red to green, suggesting the colours seen in hypersthene.

Unfortunately no crystals were available, therefore it was impossible to prove the mineral to be cassiterite, but the optical properties, apart from the pleochroism and the chemical composition, point to that identification.

I have little doubt myself that this dark mineral is cassiterite, showing abnormal pleochroism, because in undoubted specimens of that mineral I have frequently noted a less marked pleochroism of (E) carmine to (O) pale green or colourless. This pleochroism is not always equally distributed over a section, but may appear in irregular patches that suggest local variation in chemical composition. I have been informed that a similar pleochroism has been noted in a tin-bearing mineral from Nigeria, and have little doubt that it has been observed by mineralogists who have examined numerous tin-ore specimens from elsewhere. I published a note on this pleochroism in my Annual Report (Federated Malay States Government) for 1904, and have mentioned it in subsequent publications, but this specimen from Siam shows the phenomenon in a much more marked degree than any other specimen I have seen, and now that one has time to return to such matters I would suggest that the connexion between coloration, pleochroism, and chemical composition of cassiterite is a subject that might be pursued with some hope of arriving at interesting results. In crystals and in grains, viewed by reflected light, there is a wide range of colour; but in thin sections examined by transmitted polarized light the differences of coloration are more pronounced still. Pleochroism is sometimes present, sometimes not. The most distinct pleochroic effects I have seen are this deep red to green, deep brown to a lighter brown, and violet to almost colourless.

It would, of course, be necessary to examine large quantities of material before one could ascribe any particular coloration to a particular chemical constituent; but it is perhaps worth noting one point here in connexion with this Siamese mineral. One might

surmise that the TiO_2 is responsible for the pleochroism, but a titaniferous cassiterite described in the *Mineralogical Magazine* for 1911 ("Notes on Cassiterite in the Malay Peninsula," pp. 188–20), showed the brown pleochroism noted above. On the other hand, this cassiterite contained so high a percentage of iron that it could be lifted by an electromagnet; and it is possible that the iron masked any pleochroic effect that the TiO_2 might produce were no iron present.

VI.—Note on the High-level Deposits on the Chalk at Little Heath, near Berkhamsted.[1]

By Reginald A. Smith, F.S.A., British Museum.

At a meeting of the Geological Society on January 22 a section at Little Heath, near Berkhamsted, was described[1] and discussed; but both in the papers and in the discussion attention was focussed on the lower part of the section, and the gravel, which is separated by about 6 inches of bull-head from the Chalk, was assigned to the Pliocene and correlated with the Westleton Beds of Prestwich. But the upper beds have an interest of their own, especially for the archæologist who is acquainted with the work of the late Mr. Worthington Smith; and it seems worth while to point out some striking resemblances to deposits in a line running north-east of the site in question. The Little Heath strata referred to are:—

6. Surface-soil with bleached flint-pebbles from the Reading Beds . . . . . about 2 feet thick.
5. Pebbly clay and other glacial deposits, varying from . . . . . 2–20 ,, ,,
4. Stratified loamy sand . . . . . 5–6 ,, ,,

A sharp break was noticed between the loamy sands and the underlying gravels, and analogy justifies the treatment of Nos. 4–6 as a series quite distinct from the Pliocene gravel below. The length of the interval may perhaps be determined by archæological data.

No. 4 is a stratified deposit of dark reddish-brown mottled loamy sand, the entire deposit being banded with very fine lines or partings of the grey clay. An abundance of sun-cracks throughout the stratum suggest genial climatic conditions, and indicate that each separate layer became exposed to the air after deposition.

Sun-cracks in brick-earth at Caddington, 7 miles distant, were noticed many years ago and illustrated in *Man, the Primeval Savage*, p. 80, fig. 49, the interstices being filled with later deposits of the same material, in which several floors or occupation-levels were noticed and examined with interesting results. Not only were flint implements of definite types and excellent workmanship collected in situ, but flakes capable of being fitted together again were recovered in quantities, proving that there had been no disturbance of the various surfaces when brick-earth was laid down from time to time. Above the brick-earth, which often

[1] See Reports and Proceedings, Geological Society of London, January 22, in this number of the Geol. Mag., pp. 138–41 (issued January 31, 1919).

reached a thickness of 20 feet, was what Mr. Worthington Smith called a contorted drift, evidently a glacial deposit, containing ochreous implements swept from a distant surface and perhaps of earlier date than the brick-earth specimens. The same sequence with corresponding implements was observed on two sites at Caddington (595–530 feet O.D. and 250–185 feet above the Lea); at Round Green, one mile north-east of Luton (530 feet O.D. and 178 feet above the Lea); at Whipsnade, 4 miles south-west of Luton (600 feet O.D. and 166 feet above the River Ver); and at Gaddesden Row, 3 miles north of Little Heath, on the other side of the Gade (544 feet O.D. and 184 feet above the Gade). Details of the above discoveries may be found in *Archæologia*, lxvii, p. 49, and in a paper about to be published by the Society of Antiquaries.

Little Heath is 550 feet O.D., about the average level of the other sites mentioned, which all have the same relation to the chalk escarpment, and are nearly 200 feet above the nearest river. It is a reasonable view that the present valleys have been cut down to that extent since the brick-earth was laid down and covered with glacial drift, on what are now the watersheds of several rivers.

The brick-earth implements show the beginnings of Le Moustier culture and are quite unabraded. If there is one point on which the authorities agree it is that the period of Le Moustier coincided with a cold climate, some would say a glaciation. Whether this "contorted drift" is connected with the Boulder-clay found in the immediate neighbourhood is at present undecided, but it may be recalled that James Geikie connected Le Moustier with the Boulder-clay.

It is perhaps too soon to expect the discovery of implements at Little Heath, but beds 4 and 5 seem (on paper) to correspond so closely to the implement-bearing deposits to the north-east that hopes may be entertained of eventual success; so that the newly opened pit may prove to have a human interest, and even a greater scientific value than was recognized at the meeting.

VII.—Some Recent American Petrological Literature.

FOR the last few years many geologists have been unable to keep in touch with the literature of their subject, partly owing to pre-occupation with war work of various kinds and partly owing to the spasmodic arrival in this country of non-British periodicals. The following short bibliographical notes on one limited branch of geological research have been put together in the hope that they may be of use to those who are now returning to their normal avocations, by affording them some idea of what has been done in America in the way of petrological investigation during the last few years. The list makes no pretence at completeness, since the compiler is himself suffering from the difficulties mentioned above, and the abstracts have purposely been made as short as possible, giving merely the barest indication of the contents of each paper, as a guide to readers who may desire to select what is of special interest to them. If the idea meets with approval it is hoped to publish from time to time similar compilations on other branches of geology.

"The System Anorthite-Forsterite-Silica," by O. Andersen. Amer. Journ. Sci., vol. xxxix, pp. 407–54, 1915.

A detailed experimental and theoretical discussion of this system, which must be treated as one of four components, in order to account for the formation of spinel in some of the ternary mixtures. The results are applied to actual rocks, especially to varieties that contain olivine.

"Crystallization-Differentiation in Silicate Liquids," by N. L. Bowen. Amer. Journ. Sci., vol. xxxix, pp. 175–91, 1915.

Experiments were undertaken with artificial melts to determine whether sinking or floating of crystals could be obtained. Olivine and pyroxene were found to sink and tridymite to float: the rate of sinking indicates a progressive increase of viscosity with increase of silica. The results obtained are applied to the observations of Lewis on the Palisade sill, and it is concluded that sinking of crystals is of importance even in acid magmas.

"The Crystallization of Haplobasaltic, Haplodioritic, and related Magmas," by N. L. Bowen. Amer. Journ. Sci., vol. xl, pp. 161–85, 1915.

The relations of diopside to the plagioclase series are studied by the quenching method of thermal analysis. The facts determined for artificial melts are applied to their natural analogues, and it is concluded that there can be little reason to doubt that crystallization controls the differentiation of the sub-alkaline series of igneous rocks.

"The Later Stages of the Evolution of the Igneous Rocks," by N. L. Bowen. Supplement to the Journal of Geology, vol. xxiii, No. 8, 1915. 91 pp.

In this long paper Dr. Bowen gives a summary of his conclusions based on an extensive discussion of the whole problem of the evolution of the igneous rocks, taking into account the results of investigations of the course of crystallization in artificial melts and the theoretical conclusions arising from them. Assimilation and direct refusion of sediments are regarded as unimportant, since they would lead to rock-types such as are never found. The decision is reached that differentiation is controlled entirely by crystallization, mainly by sinking of crystals and squeezing out of residual liquids, and it is shown that with slow cooling typical rock-series could be formed from basaltic magma, which is probably the primitive type.

"Differentiation in Intercrustal Magma Basins," by A. Harker. Journ. Geol., vol. xxiv, pp. 554–8, 1916.

This is mainly a criticism and review of Dr. Bowen's advocacy of differentiation in situ as opposed to differentiation before intrusion. It is pointed out that increase of viscosity in a cooling body of moderate size would soon stop sinking of crystals, and the frequency of small, separate, but obviously related intrusions is insisted on. It is also shown that the great majority of the crystalline schists of igneous origin belong to the calcic branch, indicating the connexion of calcic magmas with tangential thrusting movements.

"Genesis of the Alkaline Rocks," by R. A. Daly. Journ. Geol., vol. xxvi, pp. 97–134, 1918.

An examination of recent publications has led the writer to renewed faith in the general explanation for most of the alkaline rocks advanced in *Igneous Rocks and their Origins*. Doubts are expressed as to the validity of some of Bowen's conclusions on this subject.

"Internal Structures of Igneous Rocks, their Significance and Origin, with special reference to the Duluth Gabbro," by F. F. Grout. Journ. Geol., vol. xxvi, pp. 439–58, 1918.

A study of the significance and origin of banded structures, which are found to be in nearly every case parallel to the bounding surfaces of the intrusion. The banding is attributed to convection-circulation during crystallization.

"Two-phase Convection in Igneous Magmas," by F. F. Grout. Journ. Geol., vol. xxvi, pp. 481–99, 1918.

Banding and other parallel structures in igneous rocks indicate the occurrence of convection during cooling. The idea of convection becomes of practical service when applied to banding as an indicator of the form of the intrusion, assisting in locating and orienting bands of magnetite and other economic minerals and estimating their probable position and extent.

"A Study of the Magmatic Sulfid Ores," by C. F. Tolman, jun., and A. F. Rogers. Stanford University Publications, 1916.

A microscopic and metallographic study of ore-bodies of the Sudbury type, associated with basic intrusions. It is concluded that the magmatic ores in general have been introduced at a late stage as a result of mineralizers and that the ore-minerals replace silicates. The process, however, is distinguished from pneumatolysis, since quartz and secondary silicates are not then formed. Two main types are recognized, namely, nickeliferous pyrrhotite-chalcopyrite deposits in norite and gabbro, and chalcopyrite-bornite deposits in norite and diorite.

"The Nickel Deposits of the World," by W. G. Miller and C. W. Knight. Reprinted from the Report of the Ontario Nickel Commission, Toronto, 1917.

The origin of the Sudbury ores is fully discussed, with detailed descriptions of all the mines: in opposition to the views of Coleman and others the authors consider that the sulphides were deposited from heated waters at a period subsequent to the consolidation of the norite. It is pointed out that the commercial ore-bodies form the cementing and replacing material of breccias along crushed and sheared zones, not in the norite but in the country rock, often at some distance from the contact. Analyses of the norite show little or no evidence of differentiation.

"Magmas and Sulphide Ores," by A. P. Coleman. Econ. Geol., vol. xii, pp. 427–34, 1917.

A discussion of the work of the Ontario Nickel Commission and of Tolman and Rogers on the Sudbury ores. The author maintains that the field relations there seen are in good agreement with the theory of magmatic segregation under gravity, but inconsistent with the deposit of the ores by circulating solutions.

"Magmatic Ore Deposits, Sudbury, Ont.," by A. M. Bateman. Econ. Geol., vol. xii, pp. 391–426, 1917.

A description of the field relations and characters of the nickel-bearing ore-deposits of Sudbury, with a discussion of recent views as to their origin. The author's own hypothesis is that an intermediate magma was differentiated in a reservoir and a portion was extruded to form the "nickel eruptive". This portion then continued to differentiate, giving rise to the successive portions, which vary from granite to pyrrhotite-norite and ore-bodies.

"On the Geology of the Alkali Rocks of the Transvaal," by H. A. Brouwer. Journ. Geol., vol. xxv, pp. 741–78, 1917.

A detailed petrographical description of the Bushveld complex, with a special discussion of the possible origin of the nepheline syenites and allied rock-types of the Pilandsberg area, Leeuwfontein and Lydenburg. It is concluded that these highly alkaline rocks may have been derived by differentiation from the same magma as the granites and norites of the Bushveld.

"The Problem of the Anorthosites," by N. L. Bowen. Journ. Geol., vol. xxv, pp. 209–43, 1917.

The occurrences of anorthosite in the Adirondacks and in the Morin area are described, and it is concluded that the monomineralic rocks of the anorthosite group have probably been formed by gravity-separation of femic minerals from a gabbroid magma. The remaining plagioclase liquid again separates into a basic anorthosite layer below and a lighter syenitic or granitic phase above.

(*To be continued.*)

REVIEWS.

I.—La Face de la Terre. Tome III, 4e Partie (fin). Traduit et annoté sous la direction de E. de Margerie, avec un Épilogue par Pierre Termier. pp. xv and 1361–1724, with 3 coloured maps, 2 plates, and 115 figures. Tables générales de l'ouvrage, pp. 258. Paris: Armand Colin. 1918.

IT is with great pleasure that we welcome the appearance of this the concluding instalment of the French version of *Das Antlitz der Erde*, and we congratulate M. de Margerie and his colleagues on the successful termination of their labours, in spite of the adverse conditions of the last four years. Although nominally a translation

this work should be called rather an edition. It is true that the text follows as closely as the idioms of the two languages allow the wording of the original German, but it is enriched by such a mass of new references and notes, by so many new figures and maps, that it is almost a new book: in fact, Suess brought up to date. The index volume alone is a large work in itself, and it contains some very useful tables arranged to facilitate the finding of maps and figures referring to particular subjects and areas: these alone occupy 75 pages.

It is unnecessary at this time to review the book in the ordinary sense of the word, but it is perhaps permissible to make a few remarks on certain special points that suggest themselves on reading it. In the first place it is pleasing to find that the French editors have in some cases corrected injustices with regard to the assignment of ideas to their true authors: for example, it has been the fashion in German and other foreign petrological literature to attribute the conception of Atlantic and Pacific suites of rocks to Becke, whose work was published in 1902. An additional note on p. 1542 of this volume states that the idea, though foreshadowed by Iddings in 1892, was formulated clearly for the first time by Harker in 1896, six years before Becke wrote. Although probably unintentional on the part of Suess, this sort of thing is sadly too common in German scientific writings, and such statements are often copied without verification in other countries.

As is probably well known to most people, this part of the book contains a summary of the result of the author's lifelong work, and some of the conclusions here set forth differ somewhat from those reached in the earlier volumes. Such a study as this, extending over so many years, was naturally evolutionary, illustrating the development of the author's views as knowledge increased. Of special interest is the importance attached in the chapter entitled "Les Profondeurs" to the nature of the earth's interior and the genesis of the igneous rocks. The use of the rather barbarous manufactured terms like Crofesima and Nife is significant of the trend of modern petrological thought in the way of recognizing the desirability of studying the genesis of the metallic ores as well as of the silicates; the study of the sulphides is now becoming an important part of theoretical petrology, and in this way the work of Vogt, carried out nearly thirty years ago, is bearing good fruit.

The epilogue, by M. Pierre Termier, of the Académie des Sciences, partakes rather of the nature of a panegyric of Eduard Suess, and shows clearly the veneration of the French school for the great Austrian geologist, in spite of all the events of the last few years. It brings into strong relief the influence of his work on Bertrand and others, work which has largely substantiated and amplified the ideas of the master. The labours of the French editors have carried on this tradition, and there can be no doubt that geologists who wish to gain an insight into the structure of the earth will turn to this rather than to the original German or to the English translation as an exposition of the state of knowledge on this subject at the present time.

R. H. R.

II.—The Discovery of Diamonds in South Africa. By E. J. Dunn, formerly Director of the Geological Survey of Victoria. Industrial Australian and Mining Standard, vol. lx, p. 91, 1918.

THIS article, which was reprinted in the *Mining Magazine*, November, 1918, is a very interesting and readable account of the beginnings of the South African diamond industry, and especially so since the author was present in the very early days of the discoveries, and watched the gradual growth of the mining at first hand, while he also knew personally all the men who played the chief parts in the early development.

When he first arrived on the fields in 1871 the presence of diamonds had been known for four or five years, and a considerable amount of work had been done on the river diggings; but the exodus to the dry diggings was only just taking place; the site of the De Beers Mine was a low knoll, and no one had so much as scratched the surface at this place, where the shaft is now 3,520 feet deep.

The original discovery of the diamonds was quite accidental; the first was picked up by a Bushman herd-boy who gave the "blink klip" or bright stone to his master's children to play with, and it was only after some considerable time that its value was realized. After this finds became gradually more frequent till at last the rush took place and diamonds became a serious factor in the life of the country.

Before the discovery the trade and industries of South Africa were at a very low ebb and the country had become almost bankrupt, but the herd-boy's discovery on the Orange River was the beginning of a period of prosperity which is still continuing, and to which diamonds have contributed to a very considerable extent.

III.—The Geomorphology of the Coastal District of South-Western Wellington. By C. A. Cotton. Trans. New Zealand Inst., vol. l, pp. 212–22.

THE fertile coastal district of South-Western Wellington shows certain peculiar physiographic features of comparatively modern growth which appear to be explicable as the result of alternate retreat of the shore-line under wave-attack (retrogradation) and advance of the shore-line due to accumulation of land-detritus (progradation). The author gives an interesting theoretical discussion, with diagrams, of the growth of a coastal lowland under conditions of fluctuating waste-supply, and applies his conclusions to the features of the area under review. It appears that the dominant factor in this instance is a variation in the supply of sand coming from rivers further to the north-east, rather than a fluctuation in the gravel brought down by the local streams. Other possible explanations are also considered.

IV.—The Succession of Tertiary Beds in the Pareora District, South Canterbury. By M. C. Gudex. Trans. New Zealand Inst., vol. 1, pp. 244–62, 1918.

THE Pareora district lies about half-way between Christchurch and Dunedin on the east coast of the South Island of New Zealand. The complete sequence of Tertiary beds includes representatives of the Oamaru and Pareora series, with a total thickness of about 1,250 feet. An enormous number of fossils have been collected, and their detailed occurrences are tabulated at the end of the paper. The lithological character of the beds is very variable, including sands, clays, marls, and limestones, and at the base a series of grits and conglomerates alternating with coal-seams. The coal is apparently inconstant and has a dip of 60°, so that it seems unlikely to be of commercial value: it appears to have been formed in an estuary or bay and not by growth in place.

V.—On the Age of the Alpine Chain of Western Otago. By James Park. Trans. New Zealand Inst., vol. 1, p. 160, with plate, 1918.

THE Alpine chain of Western Otago consists of folded rocks of Lower Palæozoic age, but deeply involved in the eastern folds of the chain is a remarkable narrow strip of Tertiary strata which can be traced for some 25 miles. This has been involved to a depth of at least 4,500 feet. The beds consist of conglomerate, sandstone, clay, and limestone with badly preserved fossils, the maximum thickness being about 80 feet. The fossils indicate an Oamaruian (Miocene) age, probably belonging to the upper part of this formation. This occurrence affords satisfactory evidence that the mountain-building movements took place in post-Miocene times, probably early Pliocene.

VI.—Notes on the Geology of the Tubuai Islands and of Pitcairn. By P. Marshall. Trans. New Zealand Inst., vol. 1, pp. 278–9, 1918.

THE Tubuai Islands are a scattered group situated near 23° S. lat. and 150° W. long. Little is known of their geology, and Professor Marshall has examined petrographically three stone implements brought thence: two of them are dense, rather acid basalts, while the third is a rather coarse-grained olivine basalt. None of them present any special peculiarities. An examination of a box of rock specimens sent by the Chief Magistrate of Pitcairn revealed the presence here also of fine-grained basalts, many being glassy and probably of submarine origin. Most of them contain a good deal of olivine, and are moderately basic, though less so than varieties described by Michel-Lévy, which were not represented in this collection.

VII.—The Building Stones of Queensland. By H. C. Richards. Proc. Roy. Soc. Queensland, vol. xxx, No. 8, pp. 97–157, 1918.

IN the Official Year Book of Australia for 1916 it was found necessary to remark that "there is not sufficient information available to permit of a detailed statement . . . in regard to the quantity and quality of Queensland Building Stones". This reproach is now largely removed by Dr. Richards, who has given in this paper the geological and physical characteristics of the stones available for constructional purposes. Numerous chemical analyses are quoted, and tables showing the resistance to crushing, specific gravity, absorption coefficient, etc., of many of the rocks, are provided. The paper contains many details of petrographical interest and is illustrated by eighteen photomicrographs.

VIII.—Report on the Clay Resources of Southern Saskatchewan. By N. B. Davis. Canada, Department of Mines. pp. 93, with 21 plates, 1 figure, and 2 maps. Ottawa, 1918.

THE Province of Saskatchewan contains abundant and excellent deposits of fireclay, and of clays suitable for the manufacture of all kinds of ceramic ware, especially bricks and tiles, a fact of much importance in a region devoid of building stone and with little timber. The most valuable clays are found in the lower and middle divisions of the Fort Union formation, of Eocene age, associated with silts, sands and lignite, the best of all being in the White-mud series. The Pleistocene and Recent deposits also include beds of clay suitable for making common bricks. In this report a very full account is given of the technology and properties of the clays with records of numerous tests, and a detailed description of the manner of occurrence and thickness of the beds in a great number of localities.

IX.—On the Intrusion Mechanism of the Archæan Granites of Central Sweden. By P. Geijer. Bull. Geol. Inst. Univ. Upsala, vol. xv, pp. 47–60, 1916.

THE older and younger Archæan granites of Central Sweden show characteristically different relations to the rocks invaded by them, the earlier intrusions being to a large extent connected with anticlinal structures, while among the younger batholiths two types can be discerned, the anticlinal and the transgressive. The former resemble in this respect the older gneissic granites, while the others, the Serarchæan granites of Högbom, furnish excellent examples of the features quoted by Daly in favour of the hypothesis of intrusion by overhead stoping. Many of these stoped batholiths occur in regions characterized by plateau structure, as defined by Harker; in others this relation is not so typically developed, but the structural relations are always those of the zone of fracture, with regional subsidence and faulting, in strong contrast to the conditions controlling the development of anticlinal batholiths which are associated with strong contemporaneous folding and compression of the surrounding stratified rocks.

X.—Swedish Archæan Structures and their Meaning. By P. J. Holmquist. Bull. Geol. Inst. Univ. Upsala, vol. xv, pp. 125–48, 1916.

From the evidence brought forward in this paper the following sequence of events seems probable: the porphyry-leptite rocks are the oldest known formation; they represent ashy volcanic deposits, comparable to the Keewatin. These sank in blocks into the underlying granite magma, being metamorphosed and partly assimilated. After the consolidation of this granite magma the whole was affected by dynamometamorphism, forming different varieties of gneissose and schistose rocks of varying grades of alteration, the highest grades of metamorphism being closely connected with pegmatitization. The latest eruptive masses of the Archæan consist of very acid granites, pegmatites, and aplites.

XI.—Department of Mines, Canada, Summary Report, 1917. Part B. 48 pages, with 1 text-figure. Ottawa, 1918.

This instalment of the Summary Report for 1917 contains accounts of geological reconnaissances and surveys in various parts of British Columbia and the Yukon Territory. Most of the areas dealt with contain minerals of economic value, especially gold, and mining is now being developed to a considerable extent. Most of the mineralization is evidently due to the intrusion in Jurassic and early Cretaceous times of the great igneous masses known collectively as the "Coast Batholith". More detailed work has shown the existence in many places of portions of the original sedimentary roof of this batholith in regions formerly considered to be entirely occupied by igneous rocks. This is of much importance, since most of the ores occur as contact deposits at the junction of the batholith with the older rocks.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *January* 8, 1919.—Mr. G. W. Lamplugh, F.R.S., President, in the Chair.

The following communications were read:—

(1) "On 'Wash-outs' in Coal-seams and the Effects of Contemporary Earthquakes." By Percy Fry Kendall, M.Sc., F.G.S., Professor of Geology in the University of Leeds.

The author differentiates two types of interruptions in coal-seams which have been confused under the general term of "wash-outs", "wants", "nips", or "dumb-faults". One type he believes to be due, as geological writers have mostly held, to erosion by contemporary or sub-contemporary streams which coursed through the alluvial area where the coal-material was accumulating as a species of peat. The channel thus cut was subsequently infilled with sedimentary materials.

He describes a number of examples of this type in the Midland Coalfield, some being sinuous in course and traceable over many

miles; others being of great width and of irregular form, and due possibly to shifting and meandering streams.

Split seams of the type in which the seam rejoins are kindred phenomena, but in these cases the erosion was always contemporary, and, after a channel was filled up with sediments, peat-producing plants spread completely across the infilling.

Great diversity in the phenomena of splits and wash-outs arises from the differences in the ratios of shrinkage during consolidation of the various constituents, coal undergoing a shrinkage variously estimated from $\frac{9}{10}$ to $\frac{19}{20}$ of the peat from which it is formed; mud undergoing, as Sorby showed, a considerable though lesser degree of reduction; and sand undergoing almost no reduction at all. Thus the hog-back section of split seams is due to the shrinkage of the enclosing coal-substance letting down a relatively incompressible infilling of a channel deeper in the middle than at the sides. In the process the lower surface of the sedimentary mass would flatten to adjust itself to the floor, and the top would consequently assume a curve corresponding generally with the original lower curve, but reversed. The upper element of the seam has some species of seat-earth which arches over the hog-backed inclusion.

Cannel, which the author considers to be due to a kind of vegetable pulp that underwent most of its decomposition and chemical change coincidently with deposition, acts as a substance of little compressibility; and, whenever pools of cannel-pulp took the place of an equivalent thickness of normal coal stuff, they survive as swellings in the coal-seam.

The infilling of the erosion-channels, usually of muds and sands, which often show current-bedding, sometimes includes masses of conglomerate with, in exceptional cases, boulders measuring up to three feet in length. The pebbles are almost invariably of clay-ironstone, never much rounded, and presumably the product of the erosion of the measures through which the stream has cut its way.

Other disturbances of the coal-seams, commonly miscalled "wash-outs", the author believes to be due to earthquakes, and he holds that in Coal-measure times earthquakes had an importance which has never hitherto been suspected.

The area in which our Coal-measures accumulated he supposes to have resembled generally such alluvial tracts as were the scene of the great earthquakes of Assam and New Madrid described by Mr. R. D. Oldham and Mr. Myron Fuller, save that in the Coal-measures peat-beds were piled in a much more numerous suite, and were on a vaster scale both of thickness and of area than in any part of the modern world where earthquake phenomena have been studied. Some of the effects of earthquakes in Coal-measure times might be expected consequently to be of a magnitude greater than the effects of recent earthquakes, but the types of phenomena are similar.

The formation of permanent and transient ridges, troughs and fissures, the lurching out of place of belts of the superficial strata, great displacements by the subterranean flow of quicksand, traces of "sandblows" and of the caving-in of river banks have all been recognized by the author in coal-seams.

Disturbances of this character are frequent along the margins of erosion-channels, just as earthquake-formed fissures and ridges are often marked beside recent rivers in alluvial tracts.

A striking abnormality in coal-seams consists in the intrusion into the coal of sedimentary material, or the encroachment of masses of amorphous sandstone as "rock-rolls". The author attributes these to the invasion of sands rendered mobile by excess of water, and perhaps of gas, and moving under the impulse of waves of elastic compression produced by earthquakes.

An earthquake-wave would tend to push forward the water contained in a peat-bed enclosed beneath a cover of laminated clay or mud. Where this cover was impenetrable the effect would be merely transient; where the tenacity of the cover could be overcome, or where it came to an edge through erosion or failure of deposition, water would be ejected from the peat. If this passed into a sand-bed a quite small excess of water, whether accompanied or not by the gases generated in the peat by decomposition, would be sufficient to convert the sand into quicksand; and, in turn, wherever the sand-bed itself was not confined within impenetrable laminated muds there would under the elastic strains of the earthquake be an extravasation of quicksand into adjacent beds, or its expulsion as "sand-blows" at the surface of the ground. When impenetrable mud-beds occurred in a sufficiently yielding condition, such extravasation of sands might carry these beds with them in a more or less stretched condition, and so be perpetuated as solid rolls enveloped in a wrapping of stratified shales.

Lurching of the superficial strata took place on a considerable scale. The evidence is found in the gaps (often miscalled "wash-outs") of a type usually narrow and not sinuous, in respect of which the loss of coal is compensated for by swellings or folds of the seam, or by the overriding of the seam by great flakes of coal still retaining the characteristics of the seam. These flakes always show torn and ragged edges, which are sometimes splayed out and interpenetrated by tongues of sandstone or of amorphous "clunch", and the fine laminæ of the coal preserve their parallel arrangement to the extremities of the projections without contortion. In some cases the flake has been thrown in complicated folds, and in one instance completely inverted.

The inference is that the flake of coal was not moved ("overthrust") by any tectonic stress, but that under the impulse of an earthquake a mass of unconsolidated, or but partly consolidated, peat-stuff or lignite was projected forward by its own inertia in a medium, usually of sand, which, through excess of water and gases, had only such resisting power as belongs to a fluid.

Such disturbances are (with some doubtful exceptions) always limited to single seams and their contiguous measures, and there is cumulative evidence that usually the coal-stuff, and always the measures, were unconsolidated at the time of the movement. In the overriding flakes the coal retains undistorted vegetable structures in its excessively tender "mother-of-coal" layers. The "cleat" in the overriding flakes follows the orientation general to the locality.

The gap left by the projection forward of the belt of seam is filled with an unstratified sludge-like substance, commonly containing angular masses of stratified argillaceous or arenaceous material. A very finely-contorted specimen of sandstone from a true "wash-out" shows quite plainly that the disturbance took place before the material was indurated.

In harmony with the contention that the overriding masses are not due to tectonic "overthrusts" is the fact that reversed faults are almost unknown in the coalfield, are never of considerable throw, and many collieries have never seen one.

In the roofs of many coal-seams and projecting slightly into the coal are very curious roughly conical masses of sandstone, familiar to the miners as "drops" (or by other names); but these have, so far as the author knows, hitherto escaped notice by any geological writer. They are commonly wrinkled on the surface as though partly telescoped, and often have a flange on two sides, showing that they were produced on the site of a crack. They are commonly ranged in long rows. These the author interprets as casts of the funnel-shaped orifices through which the sands surcharged with water have been expelled, an invariable accompaniment of earthquakes in alluvial tracts. The shape of these drops and their grouping negative the idea that they are infillings of orifices occasioned by escapes of gas arising from the decomposition of the peat.

Fissures filled with sand or other materials, the "sandstone dykes" of American writers, are not so common in the Midland Coalfield as in some other coalfields, as, for example, Whitehaven; but a number exist. They show contortion where passing through the seam—proving that the coal-substance had not undergone its full compression at the time when the fissure was produced.

Trough-shaped hollows, called "swilleys" or "swamps", to which some coal-seams are particularly prone, the author attributes to earthquake effects, such as the subterranean movements of sand, as quicksand. They are not tectonic, for exceedingly rarely, if ever, is more than one seam on the same vertical affected. Sometimes the formation of the swilley was coincident with the formation of the seam, as is proved by changes within the trough in the nature of the seam—particularly the occurrence of cannel.

All the phenomena here described were produced prior to the production of the larger faults of this coalfield; but minor faults, some affecting upper seams and not lower, others lower and not upper, are probably to be attributed to earthquake action.

A large number of examples of each type of phenomenon, drawn from the examination of over thirty mines in the coalfield, are discussed.

(2) "On Sandstone Dykes or Rock-Riders in the Cumberland Coalfield." By Albert Gilligan, D.Sc., B.Sc., F.G.S.

The occurrence of these sandstone dykes was brought to the notice of the author when engaged in investigations into the interruptions in the coal-seams of this area. They have been encountered at various times in pits distributed all over the Coalfield; but those

more particularly examined were met with in the workings of the Bannock Band and Main Band Seams at Ladysmith Pit, one and three-quarter miles south of Wellington Pit, Whitehaven.

The pit-shaft is 1,080 feet deep, and has been sunk through the St. Bees Sandstone, Gypsiferous Marls, Permian, and Whitehaven Sandstone to the productive Lower Coal-measures. Splendid cliff-sections of the Whitehaven Sandstone and succeeding beds, which dip southwards, can be seen in a traverse of the shore from Whitehaven southwards round Saltom Bay. The coal-workings have been opened up south of the shaft, and therefore pass under St. Bees Head.

The dykes certainly pass through the Bannock Band and Main Band Seams and the intervening measures, which are about 54 feet thick; but their full vertical extent has not been determined. Their horizontal extent is variable: the longest has been traced for more than a mile. They all run practically parallel one to the other in a direction approximately north-north-west and south-south-east. The inclination of the same dyke is not constant, but the greatest deviation from the vertical was 10° south-westwards, and in general the amount was very small. In only one case was a dyke found associated with a small fault, the displacement being 2½ feet, and even this died out in a short distance. A noticeable feature was the presence of slickensiding, approximately horizontal, on the sandstone surface. Flutings, simulating ripple-marks, were present on the sides of the sandstone forming the dyke.

The average width of the dykes was from 2 to 4 inches, but sometimes they increase to 10 inches or dwindle down to mere films. Occasionally a lateral displacement was seen when the dyke passed from one type of rock to another. Splitting of the dykes was commonly seen. Veins of calcite and barytes traverse the dykes longitudinally and transversely, while lenticles of shale and coal are also of frequent occurrence in some portions of the dykes. The contact of the coal and dyke substance was very sharply defined, the coal preserving all the normal features even when adhering to the sandstone.

In discussing the origin of the fissures and the nature of their infilling, the author draws attention to the fact that the direction of the dykes at Ladysmith is that of the main system of faults in the Cumberland Coalfield. These north-north-west and south-south-east faults profoundly affect the Lower Coal-measures at Ladysmith Pit, but do not pass up into the overlying Permian and Triassic rocks.

An examination of the cliff-sections of Saltom Bay, where dykes of the same series as those at Ladysmith Pit should emerge, shows that they are not present in the Whitehaven Sandstone and succeeding beds. The inference was therefore drawn that they were of pre-Whitehaven Sandstone age. The probable conditions which obtained at the time of the formation of the fissures and their infilling were as follows: The coal-seams through which the dykes pass had been compressed to their present thickness, while they and the associated measures were sufficiently consolidated to take a more or less clean fracture. The sea in which the deltaic material of the Whitehaven Sandstone was accumulating covered the area. Fractures

were produced by earthquake disturbances set up by movement along one of the north-north-west and south-south-east faults, and the sediment on the sea-floor ran in and sealed them up.

A mineralogical examination of the Whitehaven Sandstone and of the sandstone of the dykes shows that they have much in common, notably in the types of heavy minerals.

The sequence of events postulated supports the view of an unconformity at the base of the Whitehaven Sandstone. With regard to dykes in other parts of the Coalfield which show contortion in passing through the coal-seams, the author argues for their formation before consolidation of the enclosing measures.

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2. *January* 22, 1919.—Mr. G. W. Lamplugh, F.R.S., President, in the Chair.

The President announced that a Special General Meeting of the Society would be held on Wednesday, March 26, 1919, at 6 p.m., to consider the following Resolution of Council: "That it is desirable to admit women as Fellows of the Society."

The following communications were read:—

(1) "On the Occurrence of Extensive Deposits of High-level Sands and Gravels resting upon the Chalk at Little Heath, near Berkhamsted." By Charles Jesse Gilbert, F.G.S.

In a pit recently opened at Little Heath Common on a plateau of the Chiltern Hills, 550 feet above sea-level, the following section has been developed:—

	Thickness in feet.
6. Surface soil with bleached flint-pebbles from the Reading Beds . . . . . about	2
5. Pebbly clay and other Glacial deposits, varying from	2 to 20
4. Stratified loamy sand	5 to 6
3. Stratified coarse gravel	17
2. Dark clay, with black-coated unworn flints and small well-rounded pebbles	0 6 inches.
1. Chalk.	

The upper Glacial deposit is a pebbly clay. The pebbles, which are nearly all bleached and highly waterworn, are derived from the Reading Beds. The pebbles are almost always in a vertical position, or highly inclined, some being crushed in situ.

The clay matrix is tough and mottled, and the highly coloured tints of the clay leave little room for doubt that it has been derived from the upper part of the Reading Beds.

The Chalk flints, which are scattered in such profusion over all parts of the surrounding country, are almost entirely absent, while the small pebbles of white quartz and lydite, so abundant in the underlying gravel, are seldom met with. It seems probable that the ice must have derived its materials from a distant area. The deposit is very persistent, often cutting into and disturbing the beds beneath.

On the west side of the pit, underlying the pebbly clay, is a disturbed mass of Glacial sands and clay, of a very miscellaneous

character. The whole deposit is suggestive of an englacial origin. It is introduced in the form of a wedge or V-fault cutting into the beds beneath, the pressure having come from the west. These Glacial beds were traced to a depth of about 20 feet, when the workings in this part of the pit were discontinued. At the apex of the wedge towards the east, the beds against which it had been forced showed signs of considerable disturbance.

No deposits have been found in any way corresponding to the stratified Glacial sands and gravels which are so extensively developed at Bedmond, about five miles away to the south-east, and contain a large percentage of rocks foreign to the district.

Beneath the Glacial beds is a stratified deposit of dark reddish-brown mottled loamy sand. The entire deposit is banded with very fine lines or partings of the grey clay. Some are ripple-marked, and others are covered by sun-cracks and apparent rain-spots, indicating that each separate layer became exposed to the air after deposition. The sun-cracks are very persistent throughout the deposit, and are suggestive of genial climatic conditions.

There is almost invariably a sharp break between the loamy sands and the underlying gravels.

The gravels have often an undulating surface, even where the bedding of the sands is horizontal, and strongly resemble a series of tidal beaches.

The laminæ of the loamy sands in the hollows of the beaches do not always follow the contour-line of the beach, but are deposited more or less horizontally, occasionally with a slight local unconformity. It seems probable that the water gained sudden access through one of the beaches at a distance, depositing first the heavier burden of sand, and then the lighter parting of clay in suspension, this operation being repeated by successive storms or high tides leaving the sands high and dry during the intervals. Hence the sun-cracks and rain-spots.

The fact that the surface of the clay-partings never shows signs of erosion, either from water or from subaërial agencies, suggests that the various layers of the sands were deposited at fairly frequent intervals, and in quiet water.

The underlying gravel deposit consists almost entirely of Reading pebbles and waterworn flints in approximately equal quantities, with an occasional pebble of puddingstone from the Reading Beds. Some of the pebbles of puddingstone and of the large waterworn flints show distinct evidences of noding. No rocks foreign to the district have been found.

As a general rule, the gravel becomes coarser in depth, the lower sections containing a high percentage of large waterworn flints. In no case are the pebbles crushed as in the Glacial beds, and they usually lie quite horizontally. The spaces between the pebbles are completely filled with loose sand and small stones. The small stones are mostly Reading pebbles and white quartz, with a few pebbles of lydite. The gravel is quite homogeneous.

Recent researches appear to indicate that the quartz and lydite pebbles in this district have been derived from the Lower Greensand

(which crops out north and north-west of the Chilterns) after the final breach of the Chiltern scarp, in the gaps of which the quartz-bebbles are found in such abundance. If this be correct, it would indicate not only that the materials of which the gravels are composed came from the north, but also that the vast quantities of quartz-pebbles which are found everywhere in the upper plateau-gravels nearest to Little Heath are derived from the same source.

Reasons are adduced in support of the contention that the loamy sands and gravels are marine deposits laid down in a shallow sea; and that they cannot be of Glacial origin.

The area over which the gravels have been found extends for over a mile and a half south-east and north-west, by about half a mile north-east and south-west. They thin out towards the north-west, where they are only found in occasional outliers around which the Glacial beds rest directly upon the Chalk. It is clear that there must have been a considerable erosion of the pebble-beds before the Glacial beds were deposited.

As to the age of the loamy sands and gravels, the presence of the pebbles of puddingstone proves that they cannot be Reading Beds, and as they rest directly upon the Chalk the London Clay and Reading Beds must have been denuded before their deposition. They must be later than the Miocene movements, and are obviously pre-Glacial. They are apparently of marine origin, and their similarity to the high-plateau gravels farther south and to the beds at Headley Heath, Netley Heath, etc., suggests their contemporaneous deposition with these gravels. They are probably, therefore, of Pliocene age.

(2) "Notes on the Correlation of the Deposits described in Mr. C. J. Gilbert's paper with the High-level Gravels of the South of England (or the London Basin)." By George Barrow, F.G.S., M.I.M.M.

The gravels described in the preceding paper belong to a series of widespread deposits of which the harder constituents have usually been derived from two areas only: one within the Chalk escarpment (or local), the other beyond this escarpment, but within that of the Lower Greensand (neighbouring). The local constituents are Reading or other Tertiary pebbles, and flint; the latter is small in quantity where the gravels rest on Tertiary beds, but much increased where on the Chalk. In addition, pebbles of sarsen are not uncommon; they have been wrongly identified as quartzite. The pebbles to which the term "neighbouring" is applied consist of white quartz and lydite, all small; they have been proved to have been derived from the Lower Greensand, and this identification is corroborated by the fact that over considerable areas small fragments of chert from the Lower Greensand are associated with them.

"Far-travelled" stones, derived from the Bunter, Carboniferous Limestone, Red Chalk, etc., are entirely absent from these deposits as originally laid down.

So long as they are composed mainly of small pebbles the gravels keep at a nearly constant level over a very wide area, a little more

than 400 feet above sea-level. This type has once covered the greater part of the Thames Valley that is now at or below this level. As they rise to a greater height the Tertiary pebbles (and flints if present) increase in size.

Outliers of the finer deposits have recently been met with near Chorley Wood, and on both sides of the Misbourne a little above Chalfont St. Giles. The steady increase in the proportion of small quartz pebbles in this area suggests that they must have entered the district by the Wendover gap, at the head of the Misbourne valley; this has been proved to be the case.

The coarser gravels of this composition occur on the south side of the Thames, at varying heights, up to above 600 feet; these all rest on the Chalk. The author has pointed out that there must be corresponding coarser gravels also resting upon the Chalk on the north side of the Thames, and the occurrence described by Mr. Gilbert now shows that this is the case.

The higher gravels on the south side of the Thames seem to be allied to the Lenham Beds, and this greater age is supported by the considerable denudation that has taken place since this series of gravels was deposited. The post-Glacial denudation of the area about London, away from the immediate neighbourhood of the Thames itself, is quite small in comparison with it.

II.—Edinburgh Geological Society.

December 18.—Dr. M'Lintock, Vice-President, in the Chair.

(Received January 18, 1919.)

1. "Lead and Zinc Mining in Scotland," or "Some Scottish Mineral Veins". By G. V. Wilson, B.Sc., F.G.S.

Metalliferous mining is an old Scottish industry of which few early records exist. Gold has been worked in many places, especially the Leadhills district. In considering the source of this gold we may suppose that some auriferous quartz veins were exposed in the district prior to the Glacial Period. By the ordinary process of erosion the gold weathered out of these veins and found its way into the river gravels of the streams. The whole country was then subjected to the action of glacier ice, which removed and mixed the gravels with other materials, and deposited the whole as a boulder-clay and drift over a wide area. Since then the local streams denuded the glacial deposits and concentrated afresh the gold in a new set of river gravels. A number of auriferous quartz boulders, including one found by the writer last summer, have been picked up in the Short Cleuch water.

Silver has been found and worked native at one or two localities—notably Hilderstone and Alva.

Copper has been worked in many places—the chief being Sandlodge in Shetland; others are Kilfinnan, Bridge of Allan, Tomnadshan, and Kirkcudbrightshire.

Nickel, cobalt, and antimony have been worked to a small extent. In connection with nickel a very interesting occurrence is that at Talnotry, near Newton Stewart, where the ore occurs as a magmatic

segregation of niccolite and nickeliferous pyrrhotite, at the base of a small intrusion of hornblende gabbro near the margin of the Cairnsmore granite. The intrusion is of the nature of a sill, and thus it has affinities with the well-known Sudbury deposit in Canada.

Lead has been mined in almost every county, but in many cases the mines are now closed down. The chief mines are now at Leadhills and Wanlockhead. The veins of the Leadhills-Wanlockhead district can be divided into two main sets, one running about due north and south and the other about north-west. The north and south set are thought to be the later of the two. About seventy veins in all are known, but only three are now being worked. Leadhills mine (Glengonnar shaft) is about 230 fathoms deep, and works Brow and Brown's veins. Wanlockhead mine (Glencrieff shaft) is about 240 fathoms deep, and works the new Glencrieff vein in its west branch. At Leadhills only galena is worked, but at Wanlockhead both galena and zinc blende are obtained.

At the present time, in different parts of the new Glencrieff vein, various chemical changes are taking place: thus galena is being dissolved and calcite deposited, in others again calcite is being dissolved and hemimorphite deposited, and in others barytes is going into solution and witherite is crystallizing out. These secondary changes have much influence on the economic character of a vein, making it richer in ore. The Leadhills-Wanlockhead veins are supposed to owe their origin to the intrusion of a dome-shaped mass of granitic rock, which is not exposed, but whose presence is indicated by the numerous dykes of felsite in the area. Over the crest of the dome numerous fissures were formed in the country rock. In the final stages of the cooling of the mass large volumes of ore-bearing hot waters and gases were given off and permeated the whole area. These hot solutions found their way to the larger fissures, and there deposited their burden. Earth movements have disturbed these veins, forming fresh cavities, which have again been filled by secondary deposition of ore.

2. "The Bituminous Sands of Northern Alberta, Canada." By Lieut. S. C. Ells, 2nd C.E.R.B.

These bituminous sands, of which extensive outcrops occur in Northern Alberta, are of considerable commercial value as material for pavements of various classes. They are of Cretaceous age, and are found in a band overlying unconformably limestones of Devonian age. The sands, which vary much in quality, are always more saturated with bitumen in their lower layers, the amount decreasing upwards: from which fact it is supposed the bitumen has originated from below. A difficulty in the working of these bituminous sands is the considerable (but light in some districts) overburden of the Clear-water shales, also of Cretaceous age. Attempts have been made in the United States to separate the bitumen from the sands, to procure useful commercial products, but at present these have not been very successful. Lieut. Ells illustrated his remarks by a series of excellent slides, giving views of outcrops of the bituminous sands and the methods of working them.

III.—Mineralogical Society.

January 14.—W. Barlow, F.R.S., Past-President, in the Chair.

A. Hutchinson: "Stereoscopic Lantern Slides of Crystal Pictures." The twin pictures are projected by means of a double lantern through screens of complementary tints—red and green—and are viewed through similarly tinted screens, one for each eye. If the adjustment is correct a black and white picture stands out in relief. This method admits of the properties of crystals and of crystal structure being demonstrated simultaneously to a large number of students.—L. J. Spencer: "Mineralogical Characters of Turite (= Turgite) and some other Iron-ores from Nova Scotia." The mineral collection of the late Dr. H. S. Poole, which was presented to the British Museum in 1917, contains, amongst the iron-ores, specimens of magnetite, hæmatite, turite, goethite, limonite, chalybite, mesitite, and ankerite, from many well-defined localities in Nova Scotia. The dehydration curves and optical characters of turite ($2\,Fe_2O_3 . H_2O$), goethite ($Fe_2O_3 . H_2O$), and limonite ($2\,Fe_2O_3 . 3\,H_2O$) prove that these, at least, amongst the large group of ferric hydroxide minerals are distinct species with crystalline structure; some others are colloidal. Turite (= turgite, an incorrect German transliteration from the Russian) is a hard, lustrous, black mineral, with a radially fibrous and concentric shelly structure, and gives a dark cherry-red streak; the fibres are optically birefringent and strongly pleochroic. Sharp brilliant crystals with the forms of goethite, but consisting of anhydrous ferric oxide, i.e. pseudomorphs of hæmatite after goethite, were described.

CORRESPONDENCE.

YUNNAN CYSTIDEA.

Sir,—In bringing (quite courteously) a general charge of inaccuracy against my observations on the Yunnan Cystids, Dr. Cowper Reed (Geol. Mag., February, 1919, p. 93) has confined his instances to two. (1) As regards the diplopores of *Sinocystis loczyi*, many of which certainly appear at first sight to be covered with tubercles of epistereom, I was able to detect the minute openings, just below the apex of the tubercle, even in unworn surfaces from which I myself cleared away the matrix (Geol. Mag., Nov. 1918, p. 512, fig. 5); Dr. Reed was not able to see the openings in such unabraded tubercles. Therefore, while maintaining that the pores normally opened, I have admitted that they might occasionally become clogged. (2) I am glad to assure Dr. Reed that I have never questioned the existence of the "runnels" on the surface of *Ovocystis mansuyi*. I have only denied that they are food-grooves. Those on which I made notes from the actual specimen were attributed to a combination of causes (Geol. Mag., 1918, p. 514).

When novelties are independently described by more than one student, contradictory conclusions and divergent observations are not uncommon. The matter is then generally decided by a fresh